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(Vol. VIII, Part I, June 1946)

THE BANGALORE PRESS

THE INDIAN JOURNAL OF ENTOMOLOGY

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K. B. LAL,
Chief Editor,
Indian Journal of Entomology.

Agricultural Gardens,
Cawnpore.

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STUDIES ON THE SOMATIC MUSCULATURE OF THE DESERT LOCUST, *SCHISTOCERCA GREGARIA* (FORSKÅL)

PART II.* THE NECK AND THE PROTHORAX

By SURENDRA DEO MISRA, M.Sc.
Lecturer, Department of Zoology, The University, Lucknow

(With 7 Text-Figures)

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I. INTRODUCTION

Part I of this series (Misra, 1946) dealt with the musculature of the head-capsule of the desert locust (*Schistocerca gregaria*, phase *gregaria*). In the present part, I deal with the musculature of the neck and the prothorax. The numbering of the muscles is continued from Part I.

* For Part I (The Head), see Misra, Surendra Deo, 1946, *Indian J. Ent.*, 1945, 7: 103–38.

As in Part I, I have compared the muscles of the desert locust with those of *Anacridium aegyptium* (L.) [=*Acridium lineola*† (Farb.)] (Berlese, 1909), *Dissosteira carolina* (Snodgrass, 1929) and *Locusta migratoria* (the muscles of the head, neck and basipodite only, Uvarov and Thomas, 1942). Just before sending this paper to the press Jannone's work (1940) on *Dociostaurus maroccanus* (Thunb.), published in Italy during the War, became available to me. I have, therefore, compared only the neck and prothoracic muscles (excluding the prothoracic leg muscles, which, Jannone has not described) of the desert locust with those of *D. maroccanus*, leaving the comparison of the head musculature for the concluding portion of this series. The muscles of the neck and the prothorax being more complex than those of the head and Berlese's description of these muscles in *An. aegyptium* being rather incomplete in points of origin, course and insertion, the homologies of the muscles in *S. gregaria* with those of *An. aegyptium* have not been easy to determine, and in many cases only probable homologies could be established. Snodgrass's account of the muscles in *D. carolina* is, however, quite detailed and clear and homologies in this Acridid could be determined easily and more definitely.

Uvarov (1921; 1928, p. 148) has established that in the two phases of *Locusta migratoria* (Linn.), *viz.*, *gregaria* [*migratoria*] and *solitaria* [*danica*], the pronotum in the *gregaria* phase "is shorter, wider at the shoulder, and with a more definite constriction in the middle, with the hind angle rounded and the median keel low, straight in profile", while in the *solitaria* phase it is "relatively longer, more compressed laterally, with the shoulder narrow, the constriction in the middle feeble, hind angle acute and the median keel high, in profile convex". Later (1923) he established more or less similar phase differences in the desert locust, *S. gregaria*. Faure (1932, p. 368) in *Locustana pardalina* (Walker), *Nomadacris septemfasciata* (Serville) and *Locusta migratoria migratorioides* (Reich and Frm.) believed "that the enormous amount of muscle-contraction involved in the constant activity of legs of the hopper of the *gregaria* phase tends to alter the shape of the thorax in such a way as to bring about the constriction of the pronotum. Similarly, the increase in the length of the wings in phase *gregaria* may be connected with the great muscular activity going on in the thorax during development." Uvarov and Thomas (1942) in their study of the prothoracic musculature of *Locusta migratoria* (Linn.), phase *gregaria*, supported Faure's assumption; they also named the muscles which probably effect the pronotal changes. It is obvious that these suggestions can be verified, for any particular species, only by a detailed study and comparison of the muscles in the two phases.

† Berlese (1909) used the name "*Acridium lineola*" (Fabr.) which is the Egyptian grasshopper. The oldest name for it is *aegyptium* Linn., the name *lineola* Fabr. being a pure synonym (Kirby) 1910; Uvarov, 1923*a*). The current name for this grasshopper is *Anacridium aegyptium* (Linn.) though some authors place it in the genus *Orthacanthacris*. In Part I, the Head (Misra, 1946) also, the name "*Acridium lineola*" should, therefore, read as "*Anacridium aegyptium* (Linn.)." throughout.

As a step towards this elucidation, I have given here a detailed account of the muscles in phase *gregaria,* hoping to deal later with phase *solitaria.*

II. The Skeletal Parts

1. *The Neck** (Figs. 1, A, B, C; and 6)

The neck is not externally visible either dorsally or laterally, as it is covered over by the pronotum; it is, however, clearly visible ventrally. Dorso-laterally

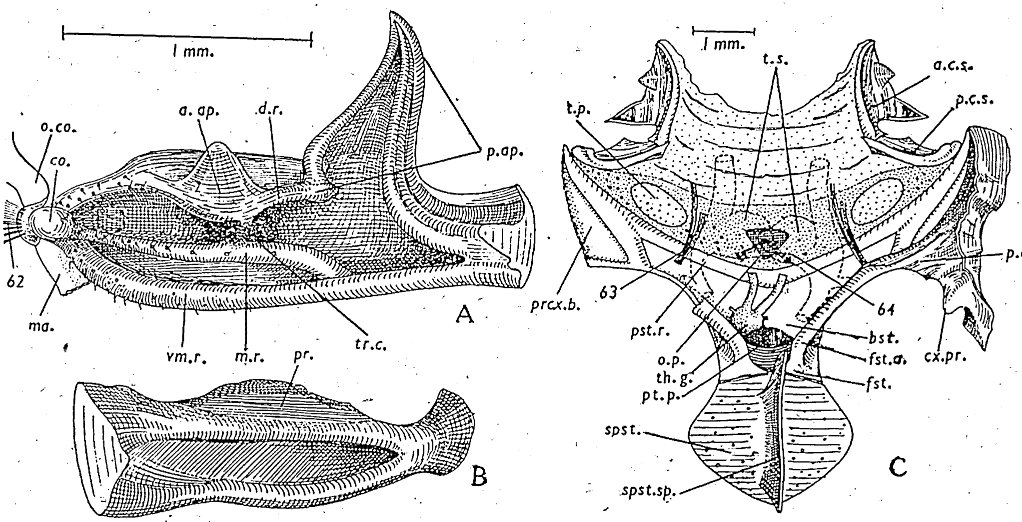

FIG. 1. A–C

A. The antero-lateral cervical sclerite. (Inner view.)

B. The posterior ventro-lateral cervical sclerite. (Inner view.)

C. The ventral region of neck and prosternum and the tracheal sacs. (Dorsal view.) The pleural apophysis and part of the pronotum attached to it have been removed on the left side to expose the pre-coxal bridge and the thoracic ganglion has been shifted towards the left side.

a.ap., anterior apodeme; *a.c.s.*, anterior ventro-lateral cervical sclerite; *b.s.t.*, basisternite; *co.*, condyle of the anterior sclerite; *cx.pr.*, coxal process; *d.r.*, dorsal ridge; *fst.*, furcasternite; *fst.a.*, furcasternal apophysis; *ma.*, part of the maxillaria of the head capsule; *mr.*, median ridge; *o.co.*, occipital condyle; *o.p.*, opaque patch; *p.a.*, pleural apophysis; *p.ap.*, posterior apodeme; *p.c.s.*, posterior ventro-lateral cervical sclerite; *pr.*, process of the posterior sclerite; *prcx.b.*, precoxal bridge; *pst.r.*, presternal ridge; *pt.p.*, pit of the prosternal spine; *spst.*, spinasternite; *spst.sp.*, spinasternal spine; *th.g.*, thoracic ganglion; *t.p.*, transparent patch; *tr.c.*, transverse connection; *t.s.*, tracheal sacs; *vm.r.*, ventral marginal ridge; **62**, cephalic muscle of the cervical sclerite; **63**, ventral elevators of the neck; **64**, protractors of tracheal sacs.

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* As Karandikar (1939) has already described the neck and the head-capsule, only those structures have been described here in detail which are directly concerned with the musculature and have not been adequately described by him.

at the lateral ends of the postocciput, the neck bears on either side a pair of diminutive *dorsal cervical sclerites,* the *upper* and the *lower.* These sclerites are formed as invaginations of the neck membrane and, therefore, appear as mere pockets on the outside but as convex thickenings on the inside. The upper sclerite bears a long wedge-shaped, tendon-like apodeme for the insertion of three of the muscles of the neck. The lower sclerite, although devoid of an apodeme, has two of the cephalic muscles inserted directly on it (Fig. 6). Karandikar's (1939, p. 24) statement that "each pocket [sclerite] is provided with an internal muscle-tendon arising from its blind end", is erroneous.

Ventro-laterally, the neck is supported on either side by a pair of *ventro-lateral cervical sclerites*, the *anterior* and *posterior*, which lie one behind the other and are hinged on each other at an angle of about 120°. The anterior sclerite is more or less boat-shaped. Its front end is narrow and bears a condyle (*co.*) attached to the post-occipital condyle (*o.co.*) of the head and the postero-dorsal part of the maxillaria (*ma.*) through a small intervening sclerite; the hind end, on the other hand, is broad. Internally it bears three longitudinal ridges called the ventral marginal, the mesial, and the dorsal. The *ventral marginal ridge* (*vm.r.*) runs all along the length of the sclerite and lies by the side of the anterior membranous part of the ventral region of the neck; its anterior half bears stout bristles on rounded chitinous tubercles. The *mesial ridge* (*m.r.*) arises from the anterior end of the ventral marginal ridge and, after running parallel to it for about half the length of the sclerite, rejoints the latter; it also bears stout bristles thickly set anteriorly but sparse posteriorly. The *dorsal ridge* (*d.r.*) arises from the anterior condyle and runs posteriorly in a wavy manner for nearly the same length as the mesial ridge; about the middle of its length it gives off dorsally a small, hollow projection (height about 0·27 mm.), the *anterior apodeme* (*a.ap.*), and ventrally joins the mesial ridge by a transverse connection (*tr.c.*); at its anterior end it bears stout bristles. Immediately behind this ridge, the posterior end of the sclerite gives off dorsally a long, prominently conical *posterior apodeme* (*p.ap.*; height about 0·79 mm.). Both the anterior and posterior apodemes appear as deep pits on the outer side of the sclerite and provide places of insertion for the muscles of the neck. The posterior ventro-lateral sclerite, which too is boat-shaped, is shorter than the anterior, has fewer ridges and no apodemes, and does not bear any bristles. Its anterior end is broad, while the posterior end is narrow and condylar and articulates with the anterior margin of the coxal piece of the episternum (*vide infra*). Along each margin it bears a longitudinal ridge, the dorsal and the ventral, the two ridges meeting at either end. The dorsal ridge is thickened in the middle to form a small process (*pr.*) for the attachment of the muscles of the neck.

Ventrally the neck is seen to be made up of two parts, thus: An anterior thin and membranous part loosely attached in front to the dorsal border of the postmentum, and a posterior thick and tough part, which is crescentic in outline and is attached behind to the prosternum. The posterior part shows three oval

cuticularized patches which represent the ventral cervical sclerites of other insects. The two later ones are larger and transparent (*t.p.*), while the median one is smaller and opaque (*o.p.*).

Karandikar (1939, p. 23) states that "these spots [patches] indicate the points of muscle-attachment on the inner side". I, however, find that no muscles are inserted on the two larger patches, and only two very thin muscle-fibres are present on the median patch. The muscles that he mentions in connection with the two large patches are, in fact, inserted internally to these patches and definitely not on them.

2. *The Prothorax* (Figs. 1, C and 2)

The tergal sclerite (pronotum or protergum) is saddle-shaped. It bears throughout its length on the dorsal surface a median ridge, the *dorsal carina* or *eel*, which is low anteriorly and high posteriorly. The pronotum consists of an

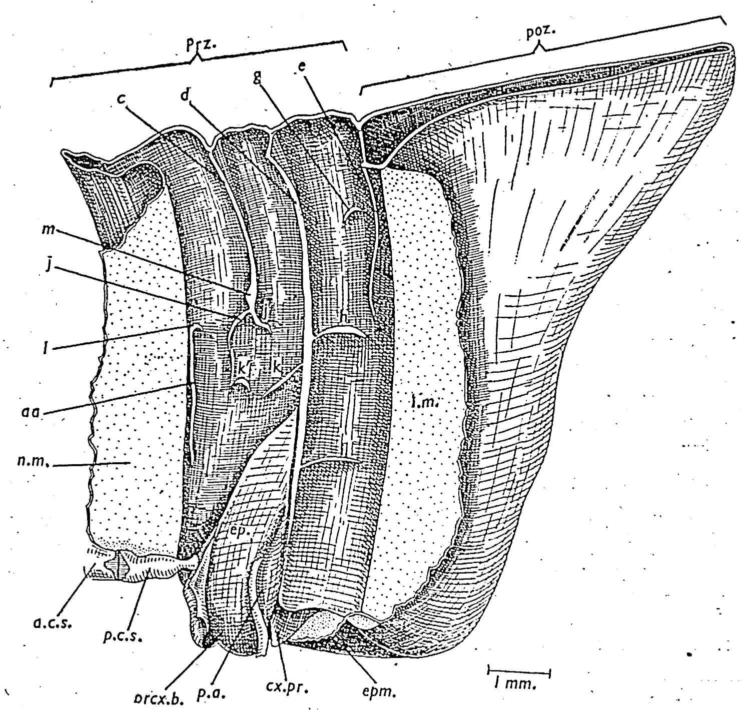

FIG. 2

The pronotum. (Inner view of the right half, showing various ridges.) The double layered character of the postzona has been exaggerated for clarity, and the ventro-lateral cervical sclerites have been stretched straight.

a.c.s., anterior ventro-lateral cervical sclerite; *cx.pr.*, coxal process; *ep.*, episternum; *epm.*, epimeron; *i.m.*, intersegmental membrane between postzona and mesothorax; *n.m.*, neck membrane; *pa.*, pleural apophysis; *p.c.s.*, posterior ventro-lateral cervical sclerite; *poz.*, postzona; *prcx.b.*, precoxal bridge; *prz.*, prozona; the various ridges are: *aa*, *c*, *d*, *e*, *g*, *h*, *i*, *j*, *j'*, *k*, *k'* *l* and *m*.

anterior part, the *prozona*, and a posterior part, the *postzona* (metazona of some writers).* The *prozona* is smooth and transparent and is concave antero-posteriorly; it bears four prominent and vertical and eight small and horizontal grooves externally, and corresponding ridges internally. Its anterior border is folded inward to join the neck-membrane. Karandikar (1939) mentions only three "transverse sulci" [vertical grooves]; he apparently missed the groove lying most anteriorly, and also all the small horizontal grooves. These grooves and the corresponding ridges are of great importance as they provide anchorage for the muscles of the head, cervical sclerites and fore-legs.

The vertical ridge *aa*† is very short and extends from about the middle of the width of the prozona to about one fourth the distance from its ventral margin; its dorsal end forms a very short hook-like process, *l*. The second ridge *c* is slightly longer than *aa;* at its dorsal end it meets its fellow of the other side, while at its ventral end it first gives off an inconspicuous process *m* and then bifurcates into two short ridges *j* and *j'*. The third ridge *d* is the longest and extends over more than three-fourths of the width of the prozona on each side; like the ridge *c*, it meets dorsally its fellow of the other side; it gives off three short horizontal ridges, *k* anteriorly and *h* and *i* posteriorly. The fourth ridge *e* is about half as long as *d* and runs parallel to the posterior margin of the prozona; the two ridges on either side meet dorsally but do not give off any horizontal ridges. Besides the horizontal ridges *l*, *j*, *j'*, *m*, *k*, *h* and *i* which are given off from the vertical ridges *aa*, *c* and *d*, there are two accessory horizontal ridges *k'* and *g*—the former (*k'*) lying anteriorly to *k* and close to the distal end of *j*, and the latter (*g*) lying between *d* and *e*.

These ridges in *S. gregaria* are more or less similar to those in *D. carolina* (Snodgrass, 1929) and *L. migratoria* (Uvarov and Thomas, 1942), but there are some differences which are detailed below:—

The ridge *aa* is absent in *D. carolina* but is present in *L. migratoria* (*a* of Uvarov and Thomas, 1942) where it joins ridge *d* ventrally by a horizontal connection but does not give off the horizontal ridge *l* at its dorsal end. The ridge *c* is present in *D. carolina* and *L. migratoria*, but the two ridges of the right and left sides do not meet dorsally, and the process *m* is absent. Moreover, in *D. carolina* *c* is connected with *d* by a horizontal connection *f* and the short ridges *j* and *j'* are absent. The ridge *d* of *D. carolina* and *L. migratoria* also differs from that of *S. gregaria* in two points: (i) That the two ridges do not meet each other dorsally; and (ii) that

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* I agree with Crampton (1918, p. 350) that it would be preferable to refer to these divisions of the pronotum as *prozona* (Crampton called it "prezona") and *postzona*, since the prefix "meta" is reserved for structures belonging to the metathorax.

†For these ridges I have followed, for facility of comparison, the alphabetical nomenclature provided by Snodgrass (1929) for *D. carolina* and by Uvarov and Thomas (1942) for *L. migratoria*. I have, however, not used the letter *b* for any ridge, since Snodgrass has used it for the anterior edge of the posterior fold of the postzona (= his metazona); Uvarov and Thomas have similarly avoided its use. The letter *a*, originally used by Snodgrass for the posterior edge of the anterior fold of the prozona, has been used by Uvarov and Thomas for an additional ridge in *L. migratoria* just behind that edge. As, however, this procedure is likely to cause some confusion I have called this ridge in *S. gregaria* as *aa* instead of *a*.

in *L. migratoria* it curves posteriorly at its dorsal end to meet the ridge *e* by a horizontal connection *g*, whereas in *S. gregaria* the ridge *g* lies between *d* and *e* and is unconnected with either. Further, the ridge *d* of *L. migratoria* has a second connection with *e* by means of the ridge *i*, and the horizontal ridge *h* instead of being connected with *d*, as in *S. gregaria*, lies between *d* and *e* and is unconnected with either. The ridge *d* of *D. carolina* differs from that of *S. gregaria* in being connected with *c* and *e* by horizontal connections *f* anteriorly and *h* posteriorly and in giving out the dorsal off-shoot *g* unconnected with *e*. The ridge *e* of the right and the left sides meet dorsally in all the three Acridids; it is longest in *L. migratoria*, covering about two-thirds the height of the pronotum; in the other two species it covers only about one-third the pronotal height. The ridge *e* of *L. migratoria* differs from that of *S. gregaria* in being connected with *d* through *g* and *i*, while in *D. carolina* it is connected through *h* alone.

Externally, the part of the prozona is swollen in front of groove *c* and constricted behind it, the constriction being most marked between grooves *d* and *e*. From the dorsal carina the prozona slopes outward and then bends vertically downward.

The *postzona* is granular and opaque and is only slightly larger than the prozona. It is a double-layered chitinous piece the posterior half of which is folded beneath the anterior half. As a result of this infolding, the posterior half is carried forward and drags with it the intersegmental membrane (*i.m.*) lying between the postzona and the anterior part of the mesothorax, both of which come to be enclosed within the postzona. The postzona has no muscles inserted on it and, consequently, it has neither any ridges nor apodemes. Externally, the larger anterior part of the dorsal surface of the postzona, forming what Uvarvo (1921) called "the shoulders of the locust", constitutes the widest part of the entire pronotum, while the smaller posterior part behind it forms a triangular process the apex of which lies between the wing-bases.

The pleural sclerite or propleuron is represented by two sclerites, the episternum and the epimeron, separated from each other by the prominent *pleural ridge*. The *episternum* is a large triangular piece closely apposed to the inner wall of the ventral part of the prozona between and below the ridges *aa* and *d*. A part of it is visible from the outside as a small triangular *precoxal piece* projecting from the antero-ventral margin of the prozona in front of the coxa of the fore-leg; the precoxal piece is folded anteriorly as well as ventrally. The anterior fold is broad and its most dorsal part provides a place for the articulation of the hind end of the posterior ventro-lateral cervical sclerite, while the ventral fold, called the *precoxal bridge,** is narrow and joins the basisternite

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* Karandikar (1939) is mistaken in calling each of the arms of the basisternite as the precoxal bridge. The latter, in all Pterygota (Snodgrass, 1935, p. 191), is "the precoxal part of the pleuron anterior to the trochantin, usually continuous with the episternum and frequently united with the sternum, sometimes a distinct sclerite". It is now generally recognised (Imms, 1937) that the pre- and post-coxal bridges are derivatives of the subcoxa. In fact, it has been demonstrated on evidence from comparative morphology (Snodgrass, 1935) and embryology (Roonwal, 1937, p. 193; 1939, pp. 56–57 in *Locusta migratoria*) that the subcoxa is converted into the pleuron, the latter having no element of the sternum in its composition.

by means of an oblique suture externally and the corresponding ridge internally. The pleural ridge gives off two triangular processes, *viz.*, a long upper one and a short lower one. The upper process is prolonged into a curved *pleural apophysis* which unites with a similar apophysis of the furcasternite (*vide infra*), the two together forming an arch on which several muscles of the prothorax are inserted. The lower process articulates with the coxa of the fore-leg and is, therefore, called the *coxal process*. The ventral part of the prozona and postzona, lying posteriorly to the pleural ridge, is internally folded upward for a short distance to form an upwardly directed pocket; the margin of this pocket is folded downward to form a second pocket, which joins the coxal process of the pleural ridge and is connected with the intersegmental membrane. The sclerite forming a double pocket is the *epimeron*.

The sternal sclerite or the prosternum is composed of three sclerites: (1) the anterior basisternite; (2) the middle furcasternite or sternellum; and (3) the posterior spinasternite. The first two sclerites are derived from the original segmental plate called *eusternum* (Snodgrass, 1135), while the third sclerite, *viz.*, the spinasternite represents the sclerotised intersternite which has joined to the preceeding segmental plate. The *basisternite* is a broad, more or less Y-shaped sclerite, the anterior arms* of which together form a crescent, while the median arm hangs down in the form of a hollow, oval process, the *prosternal spine* (not shown in Fig. 1 C), which communicates with the thoracic cavity. The anterior and postero-lateral borders of the basisternite are thickly cuticularized to form two internal ridges and their corresponding external sutures. The anterior, transversely situated ridge, the *presternal ridge* (*pst.r.*), connects the basisternite with the ventral region of the neck, while the postero-lateral or *oblique ridge* connects it with the precoxal bridge of the episternum. The *furcasternite* is a very short piece the median part of which is concealed externally behind the prosternal spine. It is invaginated on either side of the prosternal spine to form an internal process, the *furcasternal apophysis* (*fst.a.*), which gives insertion to six muscles, *viz.*, the sternopleural intersegmental (67), first and second pairs of ventral longitudinal (53 and 68), prosternal (61), the ventral elevator of the neck (63) and the sterno-spinal muscles (69). The heart-shaped *spinasternite* bears a median longitudinal groove, corresponding to the *spinasternal spine* internally which provides a place for the origin of the first and second pairs of posterior rotator muscles of the coxa (72 and 73) and the ventral longitudinal muscles of the mesothorax (to be described in the next paper of the series).

Although the sternocosta, which connects the bases of the furcasternal apophysis and its corresponding suture present in the generalised Pterygota, marks the anterior boundary of the furcasternite (Snodgrass, 1935), it cannot be made out in *S. gregaria*. However, in this insect, the line joining the bases of the furcasternal apophyses may be regarded as representing the anterior boundary of the furcasternite.

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* See previous foot-note.

3. *The Prothoracic legs** (Figs. 3 and 4)

Each of the two prothoracic legs is made up of two parts: (1) The basipodite, consisting of the trochantin and coxa; and (2) the telopodite, consisting of the trochanter, femur, tibia, tarsus and pretarsus.

(1) THE BASIPODITE

The *coxa* has the appearance of a short cylinder, broad proximally but narrow distally. It is attached to the body between the pronotum and the presternum through a membranous ring, the *coxal corium* (not shown in Fig. 3 A), and articulates directly with the pleuron at the place where the coxal process of the pleural ridge fits into the coxal notch at the antero-dorsal border of the coxa. Embedded preaxially within the coxal corium is a triangular sclerite, the *trochantin*, which gives off a tendon-like *tergal promotor apodeme* at the ventral end of its proximal border. Karandikar (1939, p. 41) has mentioned three trochantinal apodemes in which he is, no doubt, wrong—there is, infact only one apodeme, *viz.*, the tergal promotor apodeme. The proximal margin of the coxa bears an internal ridge, the *basicosta*, which corresponds to the *basicostal suture* situated externally. The narrow strip of the coxal corium extending from the distal end of the trochantin to the pleural articulation of the coxa is more thickly cuticularized than the rest. Karandikar (1939) calls this strip the basicoxite; it, however, does not extend to the "posterior extremity" of the coxal base, as stated by him, but stops short of the pleural notch. Two oval patches are seen on this strip: the outer one bears minute sensory setae, while the inner one is smooth and pouch-like. The basicosta has a shallow coxal notch (mentioned above), and two other deep notches. Of the latter, one lies immediately ventral to the coxal notch and is evaginated to form a small protuberance externally; it gives insertion to the tendon-like *abductor apodeme*. The other or *trochantinal notch* (*tn.n.*) is situated in the ventral part of the basicosta and receives the distal end of the trochantin (*tn.*).

In *S. gregaria* the trochantin does not form a second coxal articulation with the body, as it does not extend up to the pronotum. Its main function seems to be to give mobility to the coxa in the forward direction by virtue of its attachment with the coxa and the tergal promotor muscle (70) which is inserted on it by means of a tendon-like apodeme. The coxa has, therefore, a single articulation with the body. This arrangement gives it freedom of movement both in the vertical and the horizontal planes.

Along its distal border the coxa bears two notches, a broad and prominent dorsal notch (*d.n.*) and a narrow ventral notch (*v.n.*). The *dorsal notch* is covered over with a corium joining the distal border of the coxa with the proximal border

* Although Karandikar (1939) has already described the thoracic legs, the justification for the present account has been felt, firstly, because his description omits to mention the articulations of the different segments of the legs which, for a clear understanding of the working of the muscles, need to be properly described. Secondly, there are a number of inaccuracies in his description, specially regarding the apodemes on which the muscles are inserted.

of the trochanter; the outer end of its margin (not shown in Fig. 3 A) is thickened and is produced into an inconspicuous protuberance. The *ventral notch* is also covered with a corium connecting it with the proximal border of the trochanter. The triangular area between the two notches is folded on itself internally and forms the *coxal spine* (*cx.sp.*). As a result of this infolding, the corium joining the coxa with the trochanter is attached not to the outer margin of the coxal spine but to its inner folded margin. Along the preaxial border of the

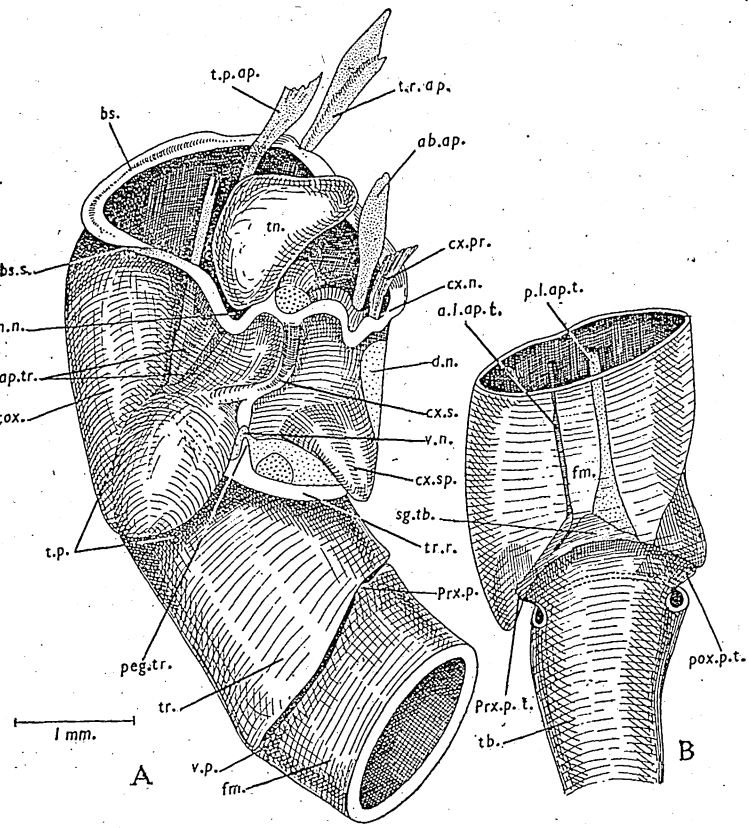

FIG. 3. A and B

A. The coxa, trochantin, trochanter and part of femur. (Anterior view.)

B. Distal end of femur and proximal part of tibia, showing the femoro-tibial articulation.

ab.ap., abductor apodeme; *a.l.ap.t.*, anterior levator apodeme of tibia; *bs.*, basicosta; *bs.s.*, basicostal suture; *cox.*, coxa; *cx.n.*, coxal notch; *cx.pr.*, coxal process of pleural ridge; *cx.s.*, coxal suture; *cx.sp.*, coxal spine; *d.ap.tr.*, depressor apodeme of trochanter; *d.n.*, dorsal notch of distal border of coxa; *fm.*, femur; *peg.tr.*, peg-like process of trochanter; *p.l.ap.t.*, posterior levator of tibia; *pox.p.t.*, postaxial articular process of tibia; *prx.p.*, preaxial articular process of femur; *prx.p.t.*, preaxial articular process of tibia; *sg.tb.*, sagittate process of tibia; *tb.*, tibia; *tn.*, trochantin; *tn.n.*, trochantinal notch; *t.p.*, triangular process of trochanter; *t.p.ap.*, tergal promotor apodeme; *tr.*, trochanter; *t.r.ap.*, tergal remotor apodeme; *tr.r.*, trochanteral ridge; *v.n.*, ventral notch of the distal border of coxa; *v.p.*, ventral articular process of femur.

coxa there runs an obliquely curved suture called the *coxal suture* (*cx.s.*); it begins from the basicosta between the pleural and trochantinal notches and ends at the ventral notch of the coxa.

(2) THE TELOPODITE

The *trochanter* is a cylindrical piece shorter than the coxa. All along its proximal sub-margin it bears internally a prominent ridge, the *trochanteral ridge* (*tr.r.*), which corresponds to an external suture. Its proximal margin is, however, produced ventrally into a long *triangular process* (*t.p.*) a part of which is enclosed by the distal border of the coxa. On account of the presence of this process, the trochanter is long and concave ventrally and short and straight dorsally. The coxo-trochanteral corium in the region of the triangular process is very loose and is folded along the sides of this process, while in the ventral notch of the coxa the corium is comparatively taut and has an oval patch bearing sensory setae. At the apex of the triangular process are inserted two tendon-like depressor apodemes (*d.ap.tr.*). Of these, the smaller dorsal one has a single limb, while the larger ventral one is two-limbed—a small anterior limb and a large posterior limb. On the preaxial side of the triangular process a *peg-like process* (*peg.tr.*) is given off through which the trochanter articulates with the coxa at the ventral notch. Along its postaxial border, the trochanter gives off a very small but strongly cuticularized process which is closely applied against the corresponding protuberance of the coxa and serves as a second articulation of the trochanter with the coxa. The distal border of the trochanter bears three inconspicuous notches—one on its preaxial (*prx.p.*), another on its postaxial and the third on its ventral aspect (*v.p.*).

The *femur* is the longest segment of the leg. Proximally it articulates with the trochanter by means of three small processes, *viz.*, the preaxial, postaxial and ventral, which are embedded in the corresponding notches of the distal end of the trochanter. The intervening areas between these processes are bridged over by coria. Distally, the femur is thickly cuticularized preaxially and postaxially. The elongated postaxial thickening marks the place where the femur is invaginated to form an internal triangular *femoro-tibial process*. Ventrally this end of the femur bears a deep oval notch covered over by a loose femoro-tibial corium. The movement of the femur on the trochanter is very much restricted, as it is articulated with the latter at three places; consequently only a slight movement is possible in the forward and upward directions. The femur largely moves only along with the trochanter as if it were part of the latter.

The *tibia*, which is slightly shorter but much more slender than the femur, lies in a vertical plane at right angles to the latter. The proximal end of the tibia is peculiar in that its dorsal part is strongly cuticularized and projects very much beyond its ventral part to form a large *sagittate process* (*sg.tb.*) which is slightly bent downward but lies telescoped within the distal end of the femur. The preaxial border of this process (*prx.p.t.*) forms a short prominence which

articulates with the preaxial thickening of the distal border of the femur. Internally to this prominence, a slender, bent process continues into a slender, tendon-like *anterior levator apodeme* (*a.l.ap.t.*). The postaxial border of the sagittate process is produced into another *articular process* (*pox.p.t.*) the distal end of which rests upon the femoro-tibial process, while its proximal part lies against the outer distal margin of the femur. Internally to this latter process is inserted a broad tendon-like *posterior levator apodeme* (*p.l.ap.t.*). The ventral part of the proximal end of the tibia is weakly cuticularized and is covered by

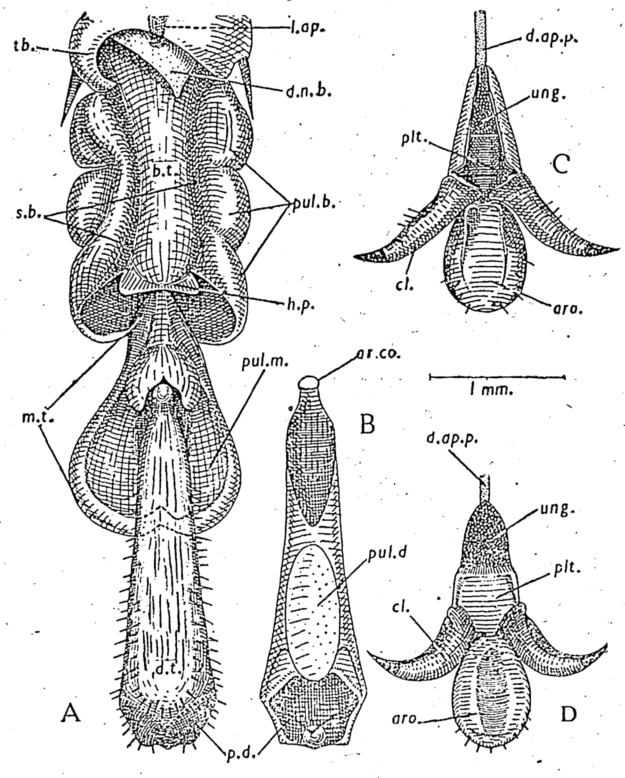

FIG. 4. A–D

A. Dorsal view of tarsus and distal end of tibia.

B. Distal piece of tarsus, in ventral view.

C. Pretarsus, in dorsal view.

D. Same, in ventral view.

ar.co., articular condyle of distal piece of tarsus; *aro.*, arolium; *b.t.*, basal piece of tarsus, *cl.*, claw; *d.ap.p.*, depressor apodeme of pretarsus; *d.n.b.*, dorsal notch of basal piece of tarsus; *d.t.*, distal piece of tarsus; *h.p.*, hood-like process of basal piece of tarsus; *l.ap.*, levator apodeme of basal piece of tarsus; *m.t.*, middle piece of tarsus; *p.d.*, double-walled process of distal piece of tarsus; *plt.*, planta; *pul.b.*, last pair of pulvilli of basal piece; *pul.d.*, pulvilus of distal piece; *pul.m.*, pulvilli of middle piece; *s.b.*, sinuous bands of basal piece; *tb.*, distal end of tibia; *ung.*, unguitractor.

the femoro-tibial corium. This corium, near its junction with the tibia, invaginates to form a very long and broad *depressor apodeme* (not shown in Fig. 3 B). The tibia bears two rows of six to eight spines in its distal half ventro-laterally, while close to its distal end it bears laterally two large spurs. The distal end of the tibia bears a crescentic notch dorsally and a similar notch ventrally.

The *tarsus* is composed of three pieces, *viz.*, the basal (*b.t.*), the middle (*m.t.*) and the distal (*d.t.*). The *basal piece* is a short tubular structure the proximal end of which is produced into two arms which separate a deep dorsal notch (*d.n.b.*) from a shallow ventral notch. These notches are covered over by loose *tibio-tarsal coria,* while the arms are telescoped within the distal end of the tibia. The corium of each of the dorsal and ventral notches invaginates to form two tendon-like apodemes, the short *levator* (*l.ap.*) in the dorsal and the long *depressor* in the ventral notch. The dorso-lateral surfaces of the basal piece are strongly cuticularized to form two sinous longitudinal bands (*s.b.*) which, at their proximal ends, strengthen the two arms. At its distal end the dorsal surface of the basal piece is folded on itself to form a *hood-like projection* (*h.p.*). The ventral surface bears two rows of three rounded pads called the *tarsal pulvilli** or *euplantulae* (*pul.b.*), the last pad of each row projecting beyond the hood-like process. The *middle piece* is the shortest segment of the tarsus and bears no tendon-like apodeme for the insertion of any muscle. At its proximal end it gives off dorsally a blunt process fitting beneath the hood-like process of the basal piece, while ventrally it bears a broad oval notch covered over by a corium connecting it with the dorsal borders of the last pair of pulvilli of the basal piece. The distal end of the middle piece bears a deep notch dorsally; the cuticle bordering the notch is folded inward and continues into the corium between the middle and terminal pieces. Ventrally the middle piece bears a pair of very large pulvilli which meet in the middle line and together form a structure very much larger than the dorsal part. The *distal piece* is the longest segment of the tarsus; it is hollow and club-shaped, narrow proximally but broad distally. This piece also has no tendon-like apodeme for the insertion of muscles. Its proximal end is thickly cuticularized dorsally to form an articular condyle (*ar.co.*) fitting closely beneath the dorsal notch of the middle piece; ventrally this end is incomplete and forms an elliptical notch covered over by a corium connecting it with the dorsal surface of the pulvilli of the middle piece. The distal end is produced dorsally into a truncated, double-walled process (*p.d.*) consisting of an outer, thickly cuticularized wall and an inner membranous corium. This process bears an internal condyle at its distal end from which radiate out two internal ridges, one on either side, to the outer border of the base of the process. Ventrally, the distal end bears a median longitudinal pad or pulvillus (*pul.d.*) on which lie numerous sensory setae; the wall of the pulvillus is double for a short distance, being folded on itself to form,

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* The term "pulvillus" is sometimes also used for the lateral lobes of the pretarsus.

on its inner side, a thickly cuticularized shallow cup the sides of which meet to corresponding borders of the corium of the dorsal process.

The *pretarsus* (Figs. 4 C, D; and 7 D; *prt.*) consists of four pieces, *viz.*, the unguitractor, the planta, the claws and the arolium. The *unguitractor* (*ung.*) is a thickly cuticularized structure which lies entirely within the shallow cup of the distal piece of the tarsus and is, therefore, invisible from outside. It is a flat, triangular piece, bluntly pointed proximally and broad distally. It is joined dorso-laterally to a corium all along its length; at its proximal end it gives insertion to the tendon-like *depressor apodeme* (*d.ap.p.*). The *planta* (*plt.*) is broader than the unguitractor and lies just distally to it beneath the dorsal process of the distal piece of the tarsus; it is, therefore, visible only ventrally, as a flat, smooth cuticularized piece. It also meets dorso-laterally the corium of the preceding piece. The *claws* (*cl.*) are two in number. Ventrally each of them is attached to the distal end of the planta at its lateral aspect, and dorsally to the corium of the planta. Dorsally at their proximal inner ends each claw is produced into a shallow triangular process, the two processes of the opposite claws being joined to each other through a membrane. Each claw bears a few bristles along its dorsal border. The *arolium** (*aro.*) is a membranous bladder-like structure lying between the two claws. Proximally, its dorsal surface bears two thickly cuticularized, crescentic projections lying side by side, each of which articulates with the triangular process of the claw of its side. Its ventral surface bears a few sensory setae.

III. THE MUSCULATURE

1. *The Musculature of the Thoracic Part of the Fore-gut (Crop and Gastric Caeca)* (Figs. 5 and 6)

These comprise two pairs of muscles which are contiguous at their places of origin, but separate out after a short distance.

(i) *The posterior protractors of the crop* (48) are a pair of very long and slender muscles (length 8·10 mm.; breadth 0·08 mm.), so called on account of their insertion on the posterior part of the crop. Each arises from the ridge *l* of its side of the prozona just externally and posteriorly to the third pair of proterga muscle of the cervical sclerite (60) and runs backward and inward, to be inserted on the dorso-lateral surface of the crop above the stomachic ganglion of its side.

(ii) *The protractors of the gastric caeca* (49) are also a pair of very long and fine muscles each of which originates from the ridge *l* contiguous with the previous muscle. As it runs backward and inward it separates out into four fine muscle-bundles to be inserted at the tips of the gastric caeca, thus: Two bundles [49 (i); length 11·20 mm.; breadth 0·07 mm.], one from each muscle of its side on the dorso-median gastric caecum; one [49 (ii); length 9·40 mm.; breadth 0·05 mm.] on the dorso-lateral; one [49 (iii); length 8·10 mm.; breadth 0·03 mm.] on the

* The arolium is sometimes also called pulvillus or empodium.

ventro-lateral; and, finally, two bundles [49 (iv); length 9·90 mm.; breadth 0·03 mm.] on the ventro-median gastric caecum.

These two muscles draw out the crop and the gastric caeca.

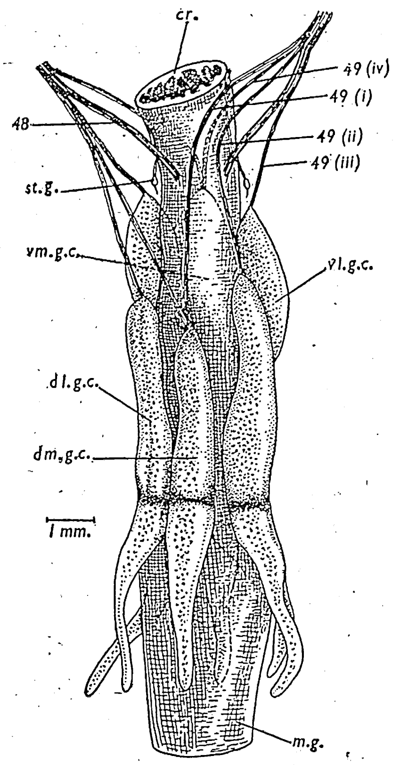

Fig. 5

Prothoracic part of the crop, mid-gut and gastric caeca in dorsal view, showing insertion of the associated muscles.

cr. prothoracic part of the crop; *dl.g.c.*, dorso-lateral gastric caecum; *dm.g.c.*, dorso-median gastric caecum; *m.g.*, mid-gut; *st.g.*, stomachic ganglion; *vl.g.c.*, ventro-lateral gastric caecum; *vm.g.c.*, ventro-median gastric caecum; **48**, posterior protractors of the crop; **49** (i–iv), protractors of the gastric caeca.

The two muscles, 48 and 49, i–iv correspond to the posterior protractors of the crop and the suspensors of the gastric caeca respectively of *D. maroccanus* and the posterior protractors of the crop and gastric caeca of *D. carolina* in origin and insertion, with this difference that each of the gastric caecum in *D. maroccanus* and *D. carolina* has one muscle-bundle each inserted on it, whereas, in *S. gregaria* the dorso- and ventro-median gastric caeca have two. Snodgrass has, however, called these two pairs of muscles as one pair, even though they are inserted on two quite different sets of structures, the crop and the gastric caeca. I have described them as two separate muscles. From Snodgrass's description it is not clear whether the dorsal and ventral median gastric caeca have one bundle each or two as in *S. gregaria*. These muscles perhaps also correspond to the "protractor muscle of the intestine" of *An. aegyptium*; Berlese has simply mentioned this muscle in the text without illustrating it, nor has he stated its origin, course or insertion.

2. *The Musculature of the Neck* (Fig. 6)

Some of the muscles of the neck are inserted directly on the head or on it through the diminutive upper and lower dorsal cervical sclerites; these muscles move the head directly. Others are inserted on the anterior or posterior ventro-lateral cervical sclerites through which the head hinges on to the prothorax; these muscles, therefore, move the head indirectly by the movement of one cervical

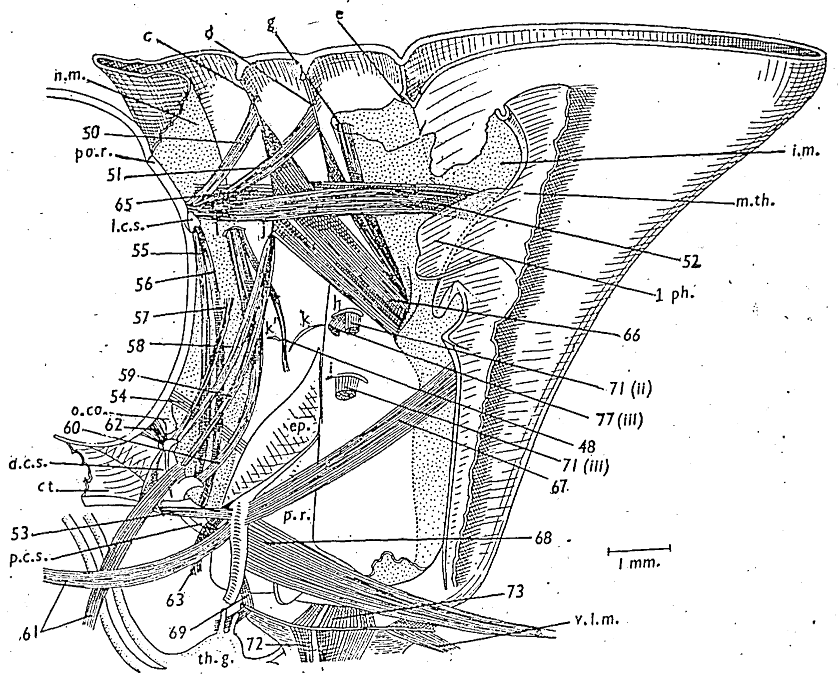

FIG. 6

Pronotum and parts of the mesothorax and head-capsule, showing the associated muscles (Inner view).

a.c.s., anterior ventro-lateral cervical sclerite; *ct.*, carpotentorium of the head-capsule; *ep.*, episternum; *i.m.*, intersegmental membrane; *l.c.s.*, lower dorsal cervical sclerite; *m.th.*, part of mesothorax; *n.m.*, neck membrane; *o.co.*, occipital condyle; *p.c.s.*, posterior ventro-lateral cervical sclerite; **1** *ph.*, first thoracic phragma; *po.r.*, postoccipital ridge; *p.r.*, pleural ridge; *th.g.*, thoracic ganglion; *v.l.m.*, ventral longitudinal muscle of mesothorax (to be described along with mesothorax); **48**, posterior protractor of the crop; **50** & **51**, first and second protergal muscles respectively of head; **52**, dorsal longitudinal muscle of head; **53**, first pair of ventral longitudinal muscle of head; **54**, ventral lateral muscle of head; **55–57**, first to third pairs respectively of cephalic muscles; **58–60**, first to third pairs respectively of protergal muscles of cervical sclerites; **61**, prosternal muscles of cervical sclerite; **62**, cephalic muscle of cervical sclerite; **63**, ventral elevator of neck; **65**, dorsal longitudinal muscle of prothorax; **66**, tergo-pleural intersegmental muscle; **67**, sterno-pleural intersegmental muscle; **68**, second pair of ventral longitudinal muscle; **69**, sterno-spinal muscle; **71 (ii, iii)**, branches of tergal remotor of coxa; **72** & **73**, first and second posterior rotators respectively of coxa; **77 (iii)**, prozonal bundle of depressor of trochanter. The various ridges are: *c, d, e, g, h, i, j, k, k'*, and *l*.

sclerite on the other. Still other muscles are inserted on the ventral region of the neck and on the tracheal sacs lying on the basisternite; these muscles perhaps effect respiration of the locust by dilating the tracheal sacs. The muscles of the neck, therefore, may be described under three heads: (*a*) Muscles that move the head directly; (*b*) muscles that move the head indirectly; and (*c*) muscles that compress and dilate the tracheal sacs.

(*a*) MUSCLES MOVING THE HEAD DIRECTLY

These comprise five pairs of muscles:

(i) *The first pair of protergal muscles of the head* (50) are short and stout (length about 2·20 mm.; breadth 0·40 mm.). Each arises from the anterior side of the ridge *c* of the prozona and runs obliquely downward and forward to be inserted, through its tendon-like apodeme, on the upper dorsal cervical sclerite.

(ii) *The second pair of protergal muscles of the head* (51) are longer (length 3·10 mm.; breadth 0·63 mm.) than the first (50). Each arises from the anterior side of the ridge *d* of the prozona and runs obliquely downward and forward to be inserted, through its tendon-like apodeme, also on the upper cervical sclerite.

(iii) *The dorsal pair of longitudinal muscles of the head* (52) are long and stout (length 4·0 mm.; breadth 2·80 mm.). Each arises externally to and at the base of the first thoracic phragma of the prothorax and runs forward almost in a straight line. It is inserted, through its tendon-like apodeme, also on the upper dorsal cervical sclerite.

The contraction of these three pairs of muscles moves the head in such a way as to bend its dorsal part backward and downward, and the ventral part forward and upward.

(iv) *The first pair of ventral longitudinal muscles of the head* (53) are also long and stout (length 2·70 mm.; breadth 0·63 mm.). Each arises from the anterior surface of the furcasternal apophysis, runs forward and is inserted on the posterior surface of the posterior tentorial arm just externally to the carpotentorium (*ct.*).

This muscle pulls the lower part of the head backward, thereby moving the dorsal part forward.

(v) *The ventral lateral pair of muscles of the head* (5*b*) are also long and stout (length 2·70 mm.; breadth 0·63 mm.). Each arises from the anterior margin of the episternum, runs obliquely forward and upward alongside the neck membrane, and is inserted on the postoccipital ridge (*po.r.*) above the place of attachment of the anterior ventro-lateral cervical sclerite.

This muscle moves the head sideways on the fulcrum provided by the ventro-lateral cervical sclerites, thereby increasing the range of movement of the mouth-parts.

The first and second protergals of the head and the dorsal pair of longitudinal muscles (50, 51, 52) of *S. gregaria* correspond to similar muscles of *D. carolina*, *L. migratoria* and

D. maroccanus as they have similar places of origin although they somewhat differ in their places of insertion. While in *S. gregaria* they are inserted together on the upper dorsal cervical sclerite, in *D. carolina*, *L. migratoria* and *D. maroccanus* they are inserted dorso-laterally on the postoccipital ridge. This small difference in insertion may be due to the absence of the dorsal sclerites on the neck in the three latter species. The first pair of protergal muscles (50) of *S. gregaria* also corresponds to the short "notocephalic" muscle of *An. aegyptium* both in origin as well as insertion—assuming that the "antecosta of pronotum", described by Berlese as the place of origin of this muscle, corresponds to the ridge *c* in *S. gregaria*. The muscle corresponding to second protergal muscle (51) of *S. gregaria* is missing in *An. aegyptium*, while the dorsal pair of longitudinal muscles (52) of *S. gregaria* corresponds to the "first dorsal jugular muscle" of *An. aegyptium*. The first pair of ventral longitudinal (53) and the ventral lateral pair of muscles (54) of *S. gregaria* correspond respectively to the first ventral longitudinal and ventral lateral muscle of *D. carolina*, *L. migratoria* and *D. maroccanus* with this difference that, although the latter muscle (54) arises from the anterior margin of the episternum in all the four Acridids, it is inserted on the postoccipital ridge (*po.r.*) in *S. gregaria*, and on the neck membrane near the postoccipital ridge in *D. carolina* and *L. migratoria* in the other three species. The first pair of ventral longitudinal muscle of the neck (53) of *S. gregaria* corresponds to the "fourth ventral jugular muscle" of *An. aegyptium*—assuming the "fork of the prostito", which Berlese describes as the place of origin of the latter muscle, to maen the furcasternal apophysis. In *An. aegyptium* there are no muscles corresponding to the ventral lateral pair of muscles (54) of *S. gregaria*.

(*b*) MUSCLES MOVING THE HEAD INDIRECTLY

These comprise eight pairs of muscles which are inserted on the anterior and posterior ventro-lateral cervical sclerites, thus:

(i) *The first pair of cephalic muscles* (55) are long and slender (length 5·40 mm.; breadth 0·81 mm.). Each arises from the dorsal lower cervical sclerite of its own side, and runs obliquely downward and backward to its insertion on the anterior edge of the posterior apodeme of the anterior ventro-lateral cervical sclerite.

(ii) *The second pair of cephalic muscles* (56) are also long and slender (length 5·85 mm.; breadth 0·90 mm.). Each arises from the lower cervical sclerite of its own side externally to the place of origin of the first pair, runs alongside the latter, and is inserted on the dorsal process of the posterior ventro-lateral cervical sclerite of its side.

These muscles pull the head backward by bending the posterior cervical sclerite on the anterior one.

(iii) *The third pair of cephalic muscles* (57) are slender (length 3·60 mm.; breadth 0·63 mm.) and are shorter than the second pair. Each arises from the neck membrane posteriorly and considerably ventrally to the lower dorsal cervical sclerite of its own side, and runs obliquely downward and forward to its insertion on the condyle of the anterior ventro-lateral cervical sclerite.

(iv) *The first pair of protergal muscles of the cervical sclerites* (58) are long and slender (length 3·15 mm.; breadth 0·63 mm.). Each arises from the ridge *j* of the prozona and runs obliquely downward and forward internally to the first and second pair of cephalic muscles of its own side. It is inserted on the

condyle of the anterior ventro-lateral cervical sclerite behind the insertion of the third pair of the cephalic muscles (57).

(v) *The second pair of protergal muscles of the cervical sclerite* (59) are also long and slender (length 3·69 mm.; breadth 0·63 mm.). Each of them also arises from the ridge *j*, but just behind the origin of the first pair of protergal muscle (58) and, like the latter, runs obliquely downward and forward. It is inserted on the outer side of the anterior apodeme of the anterior ventro-lateral cervical sclerite.

(vi) *The third pair of protergal muscles of the cervocal sclerites* (60) are also long and slender (length 4·05 mm.; breadth 0·63 mm.). Each consists of two contiguous bundles, arises from the ridge *l* of the prozona and runs obliquely downward to its place of insertion on the dorsal part of the posterior apodeme of the anterior ventro-lateral cervical sclerite of its side.

The last mentioned four pairs of muscles (57–60) push the head forward by straightening the two ventro-lateral cervical sclerites.

(vii) *The prosternal pair of muscles of the cervical sclerites* (61) are long and slender (length 3·23 mm.; breadth 0·54 mm.). Each arises from the furcasternal apophysis of the *opposite side*, runs diagonally across the other and is inserted on the inner side of the anterior apodeme of the anterior ventro-lateral cervical sclerite.

This pair of muscles evidently works antagonistically to each other and moves the head sideways.

(viii) *The cephalic muscles of the cervical sclerites* (62) are a pair of short and very stout muscles (length 0·90 mm.; breadth 0·54 mm.). Each arises from the postoccipital ridge of the head capsule below the occipital condyle (*o.co.*) and is inserted anteriorly on the condyle of the anterior ventro-lateral sclerite. This pair of muscles moveably joins the sclerite to the occipital condyle and straightens the ventro-lateral sclerites by pulling the anterior sclerites forward, thereby moving the whole head anteriorward.

The first and second pairs of cephalic muscles of the cervical sclerites (55 and 56) of *S. gregaria* correspond to the cephalic muscles of *D. carolina* and *L. migratoria*, and to the cephalic muscles of the anterior and posterior jugular sclerites [ventro-lateral cervical sclerites] respectively of *D. maroccanus* as they have similar insertions, although their places of origin are somewhat different, being on the post-occipital ridge on the last three species and on the ventral dorsal cervical sclerite in *S. gregaria*. The corresponding muscles have not been described by Berlese in *An. aegyptium*. The third pair of cephalic muscles (57) of *S. gregaria* is not present in *D. carolina*, *L. migratoria* and *D. maroccanus*. It corresponds to the "third jugular intersegmental muscle" of *An. aegyptium* where, according to Berlese, it arises from the neck membrane; its insertion, however, is not described. The first, second and third protergals of the cervical sclerites (58, 59, 60) of *S. gregaria* correspond to similar muscles of *D. carolina*, *L. migratoria* and *D. maroccanus* both in origin and insertion. The first of these (58) corresponds to the "second intersegmental jugular muscle" of *An. aegyptium* both in origin and insertion, while the other two, according to Berlese, are absent. The prosternal pair of muscles of the cervical sclerites (61) of *S. gregaria* corresponds, both in origin and insertion, to a similar pair of muscle

in *D. carolina* and *L. migratoria*, to the prosternal muscles of first jugular anterior ventro-lateral cervical sclerites] of *D. maroccanus* and to the "furco-jugular muscles" of *An. aegyptium*. The cephalic pair of muscles of the cervical sclerite (62) of *S. gregaria* is absent in *D. carolina*, *L. migratoria* and *D. maroccanus*, but is comparable to the "third dorso-ventral jugular muscle" of *An. aegyptium* in origin as well as insertion; it, however, differs from the latter in being very much shorter.

c) MUSCLES COMPRESSING AND DILATING THE TRACHEAL SACS

This group comprises two paired muscles as follows:

(i) *The ventral elevators of the neck* (63) consist of a pair of short and very slender muscles, each consisting of two bundles, one long (length 1·62 mm.; breadth 0·27 mm.) and the other short (length 1·26 mm.; breadth 0·27 mm.), arising together from the anterior surface of the furcasternal apophysis opposite the place of insertion of the sterno-pleural intersegmental muscle (67). The two bundles separate out as they run forward and downward to be inserted (the short one behind the long one) on the anterior and posterior parts of the ventral region of the neck internally to the large oval patch of its side (Fig. 1 C).

These muscles probably compress and relax the tracheal sacs situated on the ventral region of the neck by moving the floor of the prothoracic cavity upward.

(ii) *The protractors of the tracheal sacs* (64) comprise a pair of muscles even more slender and inconspicuous (length 0·52 mm.; breadth 0·03 mm.) than the previous ones. Each arises from the median patch of the posterior part of the ventral region of the neck (Fig. 1 C), runs obliquely backward and is inserted on the ventral surface of the tracheal sacs of its side which lie partly on the ventral region of the neck and partly on the basisternite beneath and a little in front of the first thoracic ganglion.

These muscles dilate the tracheal sacs.

These two pairs of muscles (63 and 64) are peculiar to *S. gregaria* and have not been described in *An. aegyptium*, *D. carolina*, *L. migratoria* and *D. maroccanus*. They are extremely fine muscles and are seen only with some difficulty. It is, therefore, quite possible that they might have been overlooked by the other workers.

3. *The Musculature of the Prothorax*

Five pairs of muscles move the prothorax on the mesothorax; they are described below.

(i) *The dorsal longitudinal muscles of the prothorax* (65) consist of a pair of long and broad band of muscles (length 4·59 mm.; breadth 1·62 mm.). Each consists of loosely set fibres originating from the junction of the intersegmental membrane with the first thoracic phragma, just externally to the place of origin of the dorsal longitudinal muscle of the head (52) of its side. It runs slightly obliquely forward, internally to the tergo-pleural intersegmental muscle (66), and is inserted on the neck membrane in front of and a little above the ridge *l* of the prozona.

(ii) *The tergo-pleural intersegmental pair of muscles of the prothorax* (66) is the most powerful of all the prothoracic muscles. Each muscle consists of four muscle-bundles which arise from the intersegmental membrane externally to and below the origin of the dorsal longitudinal muscle of the prothorax (65) of its side in front of the first basalar sclerite of the mesothorax. It runs obliquely upward and forward, to be inserted on four different ridges of the prozona, thus: On ridge *g* (length of the bundle 3·60 mm.; breadth 0·45 mm.); on the posterior side of ridge *d* (length of the bundle 3·15 mm.; breadth 1·80 mm.), a little below and opposite the place of origin of the second pair of protergal muscle of the head (51); on the posterior side of ridge *c* (length of the bundle 4·05 mm.; breadth 1·62 mm.), a little below and opposite the place of origin of the first pair of protergal muscle of the head (50); and, finally, on the ridge *m* (length of the bundle 2·79 mm.; breadth 0·72 mm.).

This powerful muscle moves the prothorax backward and inward.

(iii) *The sterno-pleural intersegmental pair of muscles of the prothorax* (67) is long and stout (length 3·96 mm.; breadth 0·72 mm.). Each muscle arises from the notch of the mesepisternal ridge of the mesothoracic pleuron and runs obliquely forward and downward to its insertion on the posterior side of the furcasternal apophysis opposite the place of origin of the first pair of the ventral longitudinal muscle of its side.

These muscles also pull the prothorax backward.

(iv) *The second pair of ventral-longitudinal muscles of the prothorax* (68) is long and wedge-shaped (length 4·59 mm.; breadth 1·80 mm.). Each muscle arises by means of a tendon from the antero-dorsal surface of the furcasternal apophysis of the mesothorax. It runs forward and is inserted on the postero-dorsal surface of the furcasternal apophysis of the prothorax outside the insertion of the sterno-pleural intersegmental muscle (67) of its side.

These muscles also pull the prothorax backward.

(v) *The sterno-spinal pair of muscles of the prothorax* (69) is very short but stout (length 1·08 mm.; breadth 0·45 mm.). Each muscle arises from the postero-ventral surface of the furcasternal apophysis and runs backward and downward, to be inserted on the outer side of the anterior tip of the spinasternal spine.

These muscles pull the sternum upward.

The dorsal pair of longitudinal muscles of the prothorax (65) of *S. gregaria* corresponds to the dorso-lateral neck muscles of *D. carolina* and probably to the "fourth dorso-nuchal muscle" of *An. aegyptium*; in *S. gregaria* and *D. carolina* the places of insertion of this muscle are alike, although the places of origin are slightly different. Thus, while in *S. gregaria* the muscle arises from the junction of the intersegmental membrane with the first thoracic phragma in *D. carolina* it arises from the first phragma. This muscle has not been described by Uvarov and Thomas in *L. migratoria* and by Jannone (1940) in *D. maroccanus*. The tergo-pleural intersegmental muscles (66) of *S. gregaria* correspond to similar muscles in *D. carolina, L. migratoria* and

D. maroccanus and to the "interphragmatic, metatergo-phragmatic and muscles of the third pronotum" of *An. aegyptium*. However, Berlese in *An. aegyptium* has given three names to the bundles of the same muscle, while Uvarov and Thomas in *L. migratoria* have separated them into two pairs; this muscle has more extensive insertion, covering the ridges *g*, *d*, *c* and *m*, in *S. gregaria* than in *D. carolina*, *D. maroccanus* (in which the insertion covers only the protergum behind the upper end of the ridge *d*), *L. migratoria* (in which the insertion is on the posterior side of dorsal part of the ridge *c*) and *An. aegyptium*. The sternopleural intersegmental muscles are alike in *S. gregaria* (67), *D. carolina*, *L. migratoria* and *D. maroccanus*; they correspond to the "second intersegmental muscle" of *An. aegyptium*, as is evident from Berlese's figure, although in his description he does not mention its place of origin. The second pair of ventral-longitudinal muscles and the sterno-spinal pair of muscles (68, 69) are also alike in *S. gregaria*, *D. carolina* and *D. maroccanus*; no mention of them has been made by Berlese in *An. aegyptium*. Of the last two muscles, Uvarov and Thomas have described only the second pair of ventral-longitudinal muscle in *L. migratoria*; they make no mention of the other.

4. *The Musculature of the Prothoracic Legs* (Fig. 7)

These muscles may be described under two heads: (*a*) Muscles of the basipodite; and (*b*) muscles of the telopodite.

(*a*) THE MUSCLES OF THE BASIPODITE

These comprise six muscles which arise from the pronotum, prosternum and episternum, as described below.

(i) *The tergal promotor of the coxa* (70) consists of four muscle-bundles which arise from the pronotum. Of these, the first, 70 (i), is long and stout (length 5·40 mm.; breadth 1·35 mm.) and arises from the lower part of the ridge *j*; the second, 70 (ii), is thinner (length 5·40 mm.; breadth 0·63 mm.) than the first and arises from the ridge *j'*; the third, 70 (iii), is stout but is shorter (length 3·15 mm.; breadth 0·54 mm.) than the first two, and arises from the ridge *k'*; while the fourth, 70 (iv), is of about the same size as the third, and arises from the ridge *k*. These bundles lie close together and run ventralward, to be inserted on the tergal promotor apodeme of the trochantin (*tn.*).

This muscle moves the leg forward and inward in a horizontal plane.

(ii) *The tergal remotor of the coxa* (71) consists of three muscle-bundles. Of these, the first, 71 (i), is long and stout (length 7·20 mm.; breadth 0·90 mm.). It arises from ridge *j'* and the upper part of ridge *j* anteriorly to the tergo-pleural intersegmental muscle (66) and internally to the second and fourth bundles of tergal promotor, 70 (i, ii). The second, 71 (ii), is shorter (length 4·50 mm.; breadth 0·54 mm.) than the first, and arises from ridge *h* internally to the place of origin of the prozonal bundle of the depressor of the trochater, 77 (iii). The third, 71 (iii), is also stout but is the shortest of the three bundles (length 3·60 mm.; breadth 0·72 mm.); it arises from ridge *i* and runs externally and posteriorly to the second bundle, 71 (ii). These three bundles are inserted postero-dorsally on the tergal remotor apodeme of the coxa, the insertion of the first bundle being separate from and slightly anterior to that of the other two.

This muscle is antagonistic to the promotor muscle (70) and moves the leg backward and outward in a horizontal plane.

(iii) *The first posterior rotator of the coxa* (72) is short and stout (length 2·43 mm.; breadth 0·90 mm.). It arises at the antero-lateral part of the spinasternal spine (Fig. 6), runs outward and backward and is inserted on the postero-dorsal part of the basicosta dorsally to the insertion of the tergal remotor muscle (71).

This muscle moves the leg in a vertical plane.

(iv) *The second posterior rotator of the coxa* (73) is a short but very stout muscle (length 2·70 mm.; breadth 1·44 mm.). It arises from the spinasternal spine of its side posteriorly to the place of origin of the first posterior rotator muscle (72) and tapers outward to its insertion on the posterior corner of the coxal base ventrally to the place of insertion of the tergal remotor muscle (71).

(v) *The abductor of the coxa* (74) consists of two fan-shaped bundles—one 74 (i), large and stout, and the other, 74 (ii), small and slender. The large bundle, 74 (i) (length 4·50 mm.; breadth 2·05 mm.), arises from the entire anterior margin of the episternum, while the small bundle, 74 (ii) (length 1·62 mm.; breadth 0·99 mm.), arises within the folded antero-ventral part of the episternum just ventrally to the place of articulation of the posterior ventro-lateral cervical sclerite. Both these bundles run backward and obliquely downward, and are inserted on the abductor apodeme, the larger one behind the smaller.

This muscle moves the leg in the forward direction.

(vi) *The adductor of the coxa* (75) is a short but powerful muscle (length 3·15 mm.; breadth 1·26 mm.). It has an extensive origin, covering the posterior surface of the upper process of the pleural ridge internally to the place of insertion of the sterno-pleural and the second pair of ventral-longitudinal muscles (67 and 68). It runs downward and slightly backward to its insertion on the postero-ventral border of the basicosta.

This muscle pulls the leg inward towards its fellow of the opposite side.

The tergal promotors of coxa, 70 (i–iv), of *S. gregaria* correspond to similar muscles in *D. carolina* and *L. migratoria* as they have identical places of origin and insertion. But, whereas there is only one compact muscle in *D. carolina*, there are two branches of it in *L. migratoria* and four stout branches in *S. gregaria*. All the other muscles of the coxa (71–75) of *S. gregaria* correspond to similar muscles of *D. carolina*. Only two of the bundles of the tergal remotors of coxa, 70 (i, ii), of *S. gregaria* correspond to the "fourth and seventh dorso-ventral muscles" of *An. aegyptium* in their origin and insertion; the remainder have not been mentioned by Berlese.

(*b*) THE MUSCLES OF THE TELOPODITE

These muscles are nine in number and move the different segments of the telopodite.

(i) *The levator of the trochanter* (76) is short and stout (length 2·34 mm.; breadth 1·44 mm.). It arises from a wide area on the postero-lateral part of the

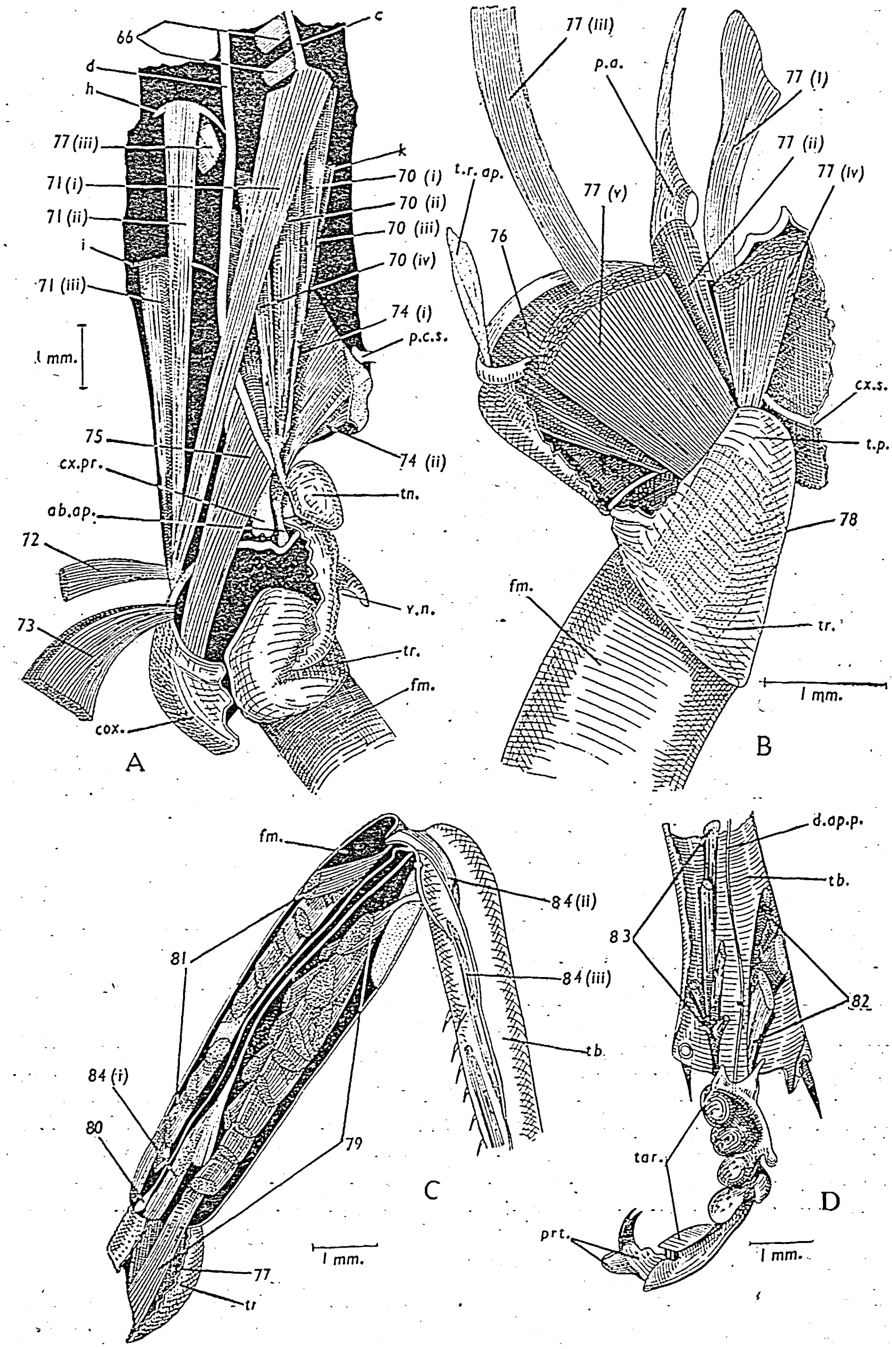

FIG. 7. A–D

A. Left coxa (cut open from the dorsal side), trochanter, and parts of femur and prozona, showing muscles of the basipodite.

B. Left coxa (cut open from the antero-dorsal side), trochanter (part of base clipped off) and a part of femur, showing muscles of the femur.

C. Left trochanter, femur (cut open from the side) and tibia, showing muscles of the last two structures.

D. Left tibia (cut longitudinally), tarsus and pretarsus, showing muscles of the tarsus.

ab.ap., abductor apodeme of coxa; *cox.*, coxa; *cx.s.*, coxal suture; *cx.pr.*, coxal process o pleural ridge; *d.ap.p.*, depressor apodeme of pretarsus; *fm.*, femur; *p.a.*, pleural apophysis; *p.c.s.*, part of posterior ventro-lateral cervical sclerite; *prt.*, pretarsus; *tar.*, tarsus; *tb.*, tibia; *tn.*, trochantin; *t.p.*, triangular process of trochanter; *tr.*, trochanter; *t.r.ap.*, tergal remotor apodeme of coxa; *v.n.*, ventral notch of distal border of coxa; **66**, bundles of tergo-pleural inter-segmental muscle; **70 (i–iv)**, tergal promotor of coxa; **71 (i–iii)**, tergal remotor of coxa; **72 & 73**, first and second posterior rotators respectively of coxa; **74 (i, ii)**, abductor of coxa; **75**, adductor of coxa; **76**, levator of trochanter; **77 (i–iv)**, depressor of trochanter; **78**, reductor of femur; **79**, depressor of tibia; **80**, anterior levator of tibia; **81**, posterior levator of tibia; **82**, levator of tarsus; **83**, depressor of tarsus; **84**, **(i–iii)** depressor of pretarsus. The various ridges are: *c*, *d*, *h*, *i*, and *k'*.

coxal base, runs forward and outward, and is inserted dorsally on the trochanteral ridge in front of the post-axial articular process of the trochanter.

(ii) *The depressor of the trochanter* (77) consists of five muscle-bundles. Of these three have their origin in the prozona and may be called the *prozonal bundles*, while the other two arise in the coxa and may be called the *coxal bundles* of the depressor.

The prozonal bundles run as follows:

The episternal bundle. 77 (i), is long and stout (length 4·50 mm.; breadth 0·63 mm.). It arises from the antero-dorsal border of the episternum internally to the place of origin of the large bundle of the abductor of the coxa. 74 (i), and is inserted on the anterior limb of the ventral depressor apodeme. *The pleural bundle*, 77-(ii). is shorter and thinner (length 2·16 mm.; breadth 0·36 mm.) than the episternal. It arises from the inner edge of the lower part of the pleural ridge and is inserted on the posterior limb of the ventral depressor apodeme. *The prozonal bundle*, 77 (iii), is the largest (length 5·85 mm.; breadth 1·17 mm.) of all the three bundles. It arises from ridge *h* of the prozona externally to the second tergal remotor of the coxa, 71 (ii), and is inserted on the dorsal depressor apodeme.

The two coxal bundles run as follows:

The anterior coxal bundle, 77 (iv), is stout and stumpy (length 1·35 mm.; breadth 0·90 mm.). It arises antero-dorsally from the basicosta and is inserted on the antero-ventral side of the triangular process close to the ventral depressor apodeme. *The posterior coxal bundle*, 77 (v), is much stouter (length 1·44 mm.; breadth 1·35 mm.) than the anterior bundle, but is equally short. It arises from the postero-ventral wall of the basicosta and the coxa and is inserted on the postero-ventral side of the triangular process close to the ventral depressor apodeme.

The two coxo-trochanteral articulations together form a more or less horizontal axis on which the trochanter moves vertically on the coxa. The trochanter, along with the femur, forms a *lever of the first order*—the triangular process of the trochanter forms the short arm of the lever, while the body of the trochanter and the femur together form the long arm. The tibia, tarsus and pretarsus serve as the weight at the distal end of the lever, while the power is supplied by the depressor muscle-bundles at the end of the short arm of the lever. These bundles, having to work on a very short arm of the lever, are obviously at a mechanical disadvantage which, however, is fully set off by the great development of these bundles. The resultant effect is that the short arm of the lever, worked by powerful depressor muscle-bundles, has to move only through a short range, while it allows a large range of movement to the weight end of the lever, *viz.*, the distal end of the femur.

When the levator muscle contracts, the dorsal part of the trochanteral ridge is pulled downward and the body of the trochanter, along with the rest of the telopodite, is lifted upward. On the other hand, when the depressor muscle-bundles contract, the triangular process of the trochanter is pulled upward, and the body of the trochanter, along with the rest of the telopodite, is depressed. This vertical movement is facilitated by the looseness of the coxo-trochanteral corium around the triangular process ventrally, and by the flexibility of the corium dorsally.

(iii) *The reductor of the femur* (78) is a stout and stumpy muscle (length 1·08 mm.; breadth 0·72 mm.). It arises from the antero-ventral wall of the trochanter, runs obliquely backward and outward and is inserted on the postero-ventral part of the femoral ridge internally to its post-axial articulation with the trochanter.

(iv) *The depressor of the tibia* (79) is a very long and stout muscle (length 8·55 mm.; breadth 1·80 mm.); the greater part of it is lodged within the femur and only a small part lies within the trochanter. It consists of numerous short muscle-bundles which arise from the dorsal wall of the trochanter and the entire dorso-lateral wall of the femur. They are inserted in a pinnate manner, bundle after bundle, on the depressor apodeme of the tibia. This muscle pulls the tibia downward.

(v) *The anterior levator of the tibia* (80) is also a very long but slender muscle (length 3·01 mm.; breadth 0·12 mm.), almost tendon-like in appearance, in which the muscle-fibres can be recognized only with some difficulty. It arises from the dorsal wall of the femur close to its antero-dorsal articulation with the trochanter, runs distally and is inserted on the anterior levator apodeme. All along its course it is embedded within the bundles of the depressor muscle.

(vi) *The posterior levator of the tibia* (81) is long and stout (length 6·75 mm.; breadth 1·26 mm.) like the depressor (79). It consists of numerous short muscle-bundles which arise all along the distal wall of the femur above the depressor

muscle and are inserted in a pinnate fashion, bundle after bundle, on the posterior levator apodeme of the tibia.

The tibia, like the trochanter, acts as a *lever of the first order* in which the sagittate process serves as the short arm and the body of the tibia as the long arm. The two femoro-tibial articulations, forming a horizontal axis, serve as the fulcrum on which the tibia moves in a vertical plane. When the two levator muscles on the short arm contract, the sagittate process is depressed and the distal end of the tibia is raised. At this stage only a slight forward movement of the femur, caused by its reductor muscle, is sufficient to swing the tibia forward to a marked extent.

The depressor muscle works antagonistically to the two levators and bends the tibia to such an extent that its proximal part comes to lie within the concave femoro-tibial corium between the lateral margins of the ventral notch. In this way the co-ordinated action of the levator and depressor muscles of the tibia and reductor muscles of the femur cause the locomotion of the locust.

(vii) *The levator of the tarsus* (82) is a short but stout muscle (length 3·15 mm.; breadth 0·53 mm.). It consists of several bundles all of which arise antero-laterally from the distal third of the tibial wall and converge to their insertion on the levator apodeme.

This muscle lifts the tarsus upward.

(viii) *The depressor of the tarsus* (83) is larger (length 4·32 mm.; breadth 0·72 mm.) than the levator, and consists of numerous muscle-bundles. The latter arise all along the length of the tarsus from the ventro-lateral wall of the tibia and are inserted in a pinnate manner on the depressor apodeme.

(ix) *The depressor of the pretarsus* (84) consists of three branches which are quite distinct from one another. These branches are peculiar in that they arise far away from the pretarsus itself and, in fact, have their origin in the bases of the femur and tibia. The three branches are as follows:

(*a*) *The femoral branch*, 84 (i), is the largest of all (length 4·32 mm.; breadth 0·63 mm.). It consists of compact fibres which arise dorsally from the base of the femur just posteriorly to the place of origin of the anterior levator of the tibia. After traversing about a third of the length of the femur, it is inserted on the flattened tape-like depressor apodeme of the pretarsus.

(*b*) *The first tibial branch*, 84 (ii), is the shortest (length 2·79 mm.; breadth 0·27 mm.), and arises from the apex of the sagittate process of the tibia. After traversing a short distance, it is inserted on the depressor apodeme of the pretarsus.

(*c*) *The second tibial branch*, 84 (iii), is larger (length 2·79 mm.; breadth 0·36 mm.) than the first tibial but smaller than the femoral branch. It arises posteroventrally from the wall of the tibia proximally to the topmost spines of

the two ventro-lateral rows. After running a short distance downward, it is inserted on the depressor apodeme of the pretarsus.

All these muscles, *viz.*, 76–84 (i–iii), correspond to similar muscles in *D. carolina*. Berlese and Uvarov and Thomas have not described the muscles of the telopodite of *An. aegyptium* and *L. migratoria* respectively; and Jannone has described only the muscles of the median leg in *D. maroccanus*.

IV. SUMMARY

1. A complete account of the dorsal, ventro-lateral and ventral cervical sclerites, the pronotum and the prothoracic legs of the desert locust, *Schistocerca gregaria* (Forskål), phase *gregaria*, is given. This includes the various apodemes and ridges, particularly those of the cervical sclerites and the prozona which have been altogether ignored by Karandikar (1939); they are of great importance for the present study, since they provide places of origin and insertion for the muscles.

2. There are two pairs of protractor muscles of the crop and gastric caeca which are contiguous at their places of origin but separate out after a short distance; one (48) is inserted on the crop, while the other 49 (i-iv) gives out fine muscle bundles to the gastric caeca; the dorso- and ventro-median gastric caeca have two muscle-bundles each from muscles of either side, while the remaining four have one muscle-bundle each. Such a distribution of the muscle-bundles of a single pair of muscles has not been noted in any other Acridid worked out so far.

3. Five pairs of muscles (50–54) move the head directly; eight (55–62) move it indirectly. Of these latter, two (57 and 62) are new to *S. gregaria* for they have not been noted in *D. carolina* (Snodgrass, 1929), *L. migratoria* (Uvarov and Thomas, 1942) and *D. maroccanus* (Jannone, 1940).

4. The ventral elevators of the neck (63) and the protractors of the tracheal sacs (64) are peculiar to *S. gregaria* and are likely to be of great interest in the study of the physiology of respiration. As far as I know, no such muscles inserted on tracheal sacs have been noted in any Acridid so far.

5. Five pairs of muscles (65–69) move the prothorax on the mesothorax, six muscles (70–75) move the basipodite (coxa), two (76 and 77) move the trochanter, one (78) moves the femur, three (79–81) move the tibia, two (82–83) move the tarsus and, finally, one (84) moves the pretarsus. The movement of the trochanter and the tibia have been compared to the working of the *lever of the first order*.

V. ACKNOWLEDGMENTS

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A NOTE ON THE LARVA OF *TROX PROCERUS* HAR. (SCARABAEIDAE, COL.)

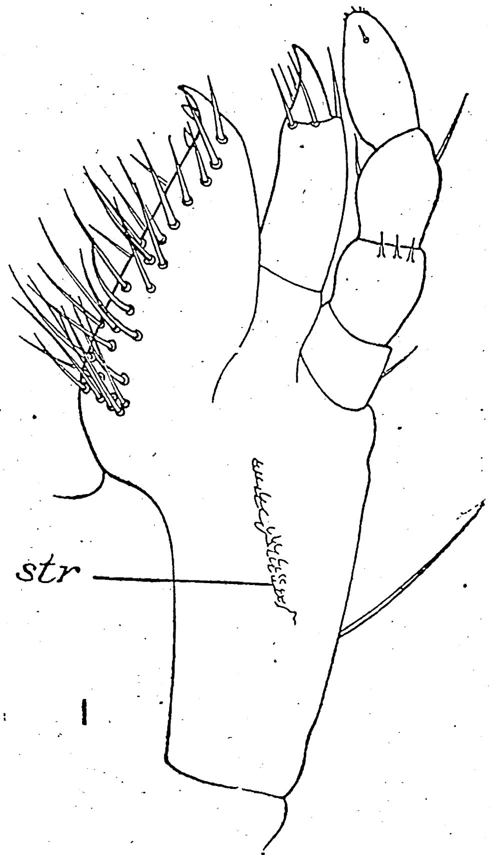
By J. C. M. Gardner
Forest Research Institute, Dehra Dun

In 1942, Dr. H. S. Pruthi sent me for identification some larvae that had been collected at Bharatpur, Rajputana, and were suspected to be feeding on eggs of the locust *Schistocerca gregaria* Forsk. With the aid of the keys of Boving and Craighead (1931, Larvae of the Coleoptera, *Brooklyn ent. Soc.*, 51) and of van Emden (1941, *Ent. month. Mag.*, 77:119) I concluded that the larvae belonged to the genus *Trox* although they differed from the descriptions in one important character. Later Dr. Pruthi sent me an adult with its larval exuviae from the same source; this proved to be a *Trox* that I was unable to identify as a known Indian species and was recently determined through the Imperial Institute of Entomology as *Trox procerus* Har., previously known from Egypt, Arabia and Senegal.

Subfamily characters of larvae of the Troginae.—The two lobes of the maxillae entirely separate and the penultimate segment of antenna with a small apical sensorial appendage (as in other subfamilies of the Laparosticti); antenna three-segmented; abdominal segments (except at posterior extremity of body) each divided into three sharply defined folds, each fold with a row of spinules; apex of abdomen with three anal lobes; legs without stridulating organs, the third pair slightly longer than the others; claws long and pointed.

So far the larva of *T. procerus* agrees with the characters given in the keys cited above which are based on six or seven species of *Trox*, but while it is stated in those keys that stridulatory organs are absent from maxillae and mandibles, the larva of *T. procerus* has a distinct row of stridulatory granules on the maxillae.

The larva of T. procerus *Har.*—Head dark castaneous, the frontal sutures sharply defined, the frons with a transverse row of depressions, the middle two elongate; a circular pit lateral to the middle of the frontal suture on each side; clypeo-frontal suture straight. Antenna with basal segment about three times as long as wide, the second three-fifths as long as that, the third small. Labrum rather strongly convex above but depressed antero-medially, nearly symmetrical. The maxillae as figured; the stridulatory granules distinct, mostly in two irregular rows. Each of the three dorsal folds of the first six abdominal segments with a transverse row of articulated spinules in addition to some fine setae; a few obscure spinules on the first fold of the seventh tergum. Spiracles more or less circular, weakly sclerotised, cribriform, the outer surface transversely divided by fine parallel lines supported from beneath by fine branches from two nearly parallel and rather wide trunks; the perforations small and rather sparse.



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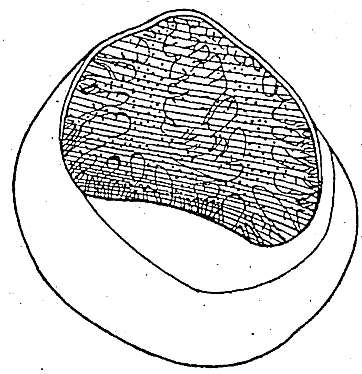

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FIG. 1. *Trox procerus* Har., dorsal view of right maxilla of larva showing separated lacinia and galea and stridulatory granules (*str.*).

FIG. 2. Spiracle of same.

FIG. 3. Spiracle, part of plate greatly enlarged.

In some species of *Trox* the spiracles are stated to be biforous and this applies to the cosmopolitan species *T. scaber* L.

INSECT FAUNA OF AFGHANISTAN—III. COLEOPTERA

By TASKHIR AHMAD, PH.D. (CANTAB.)
Imperial Agricultural Research Institute, New Delhi

In this contribution, the third of the series, the Coleopterous fauna of Afghanistan collected by the writer during a tour of that country as member of the Indian Agricultural Delegation in 1939 is described. The material comprises about 61 species belonging to 18 families of the order Coleoptera. This was identified chiefly with the help of the Imperial Pusa Collection at the Imperial Agricultural Research Institute, New Delhi, and partly through the courtesy of the Forest Entomologist, Forest Research Institute, Dehra Dun, and the Imperial Institute of Entomology, London. Their help is gratefully acknowledged.

The earliest record of Coleoptera from Afghanistan was based on a collection made by Aitchison in 1885, Naturalist attached to the Afghanistan Delimitation Commission. His collection contained about 50 species, of which only two are represented in the writer's collection. Von Heyden's contribution (1894) to this group is the largest and deals with 27 species, of which again only two are contained in this collection. The most recent addition to our knowledge of Coleoptera of Afghanistan is that due to the collection brought by Scheibe, the Leader of the German Hindukush Expedition (1935) and worked upon by various specialists (1936–1938). Of his 86 species, seven are represented in the present collection. Thus it is interesting to find that out of 61 species of Coleoptera reported in this contribution, over 50 are new records for Afghanistan.

Of the various families represented in the present collection, Coccinellidae are the most abundant, Carabidae, Meloidae, Chrysomelidae, Curculionidae, Cetoniidae and Rutelidae are fairly common and the rest are rather scarce. About 50% of the species, *viz.*, 30 out of 63 are known from India particularly its Northern and North-Western regions. This is of great interest to zoo-geographical students who will notice that there is a strong element of Afghan fauna in Baluchistan, Kashmir and other parts of North-West India.

Furthermore it may be added that the notes on biology and food plants of these species as observed in Afghanistan are entirely new for all the species described here, as previous collectors have not furnished such information.

A list of species collected by the writer is given below, while a complete list of species recorded by previous workers is appended at the end of the paper.

LIST OF SPECIES COLLECTED BY THE WRITER FROM AFGHANISTAN

I.	Cicindelidae ..	*1.	*Cicindela bigemina* Kl. var. *brevis* Horn
II.	Carabidae ..	2.	*Acupalpus* (*Egadroma*) *marginatus* Dej.
		3.	*Calosoma maderae* (Fab.)
		4.	*Hypolithus* sp.
		*5.	*Omophron rotandatus* Chd.
		*6.	*Pheropsophus catoirei* (Dej.)
		*7.	*Tachys* sp.
III.	Staphylinidae ..	8.	*Aleochara* (*Heterochara*) *glasunowi* Luze
		*9.	*Paederus fuscipes* Curt.
		10.	*Philonthus* sp.
IV.	Coccinellidae ..	*11.	*Adalia decempunctata* L.
		*12.	*Adalia tetraspilota* Hope
		*13.	*Adonia variegata* Goeze
		14.	*Aiolocaria mirabilis* Motsch.
		15.	*Coccinella conglobata* L.
		*16.	*Coccinella* 11-*punctata* L. var. *menetriesi* Muls.
		*17.	*Coccinella septempunctata* L.
		*18.	*Epilachna dodecastigma* Muls.
		19.	*Exochomus flavipes* Thunbg. ab. *nigripennis* Er.
		20.	*Halyzia* sp. (prox. 16-*guttata* L.)
		21.	*Halyzia tschitcherini* Sem.
		22.	*Scymnus* sp.
V.	Dryopidae ..	23.	*Dryops jeanneli* Boll.
VI.	Heteroceridae ..	24.	*Heterocerus* (*Litorimus*) *obliteratus* Kiesw.
		25.	*Heterocerus* sp.
VII.	Buprestidae ..	*26.	*Sphenoptera lafertei* Thoms.
VIII.	Elateridae ..	27.	*Agrypnus* sp.
IX.	Meloidae ..	28.	*Epicauta erythrocephala* Pall.
		29.	*Mylabris damascena* Rch.
		*30.	*Mylabris phalerata* Pall.
		31.	*Mylabris* sp.
X.	Anthicidae ..	*32.	*Anthicus crinitus* Laf. var. *communimacula* Frm.
XI.	Bruchidae ..	33.	*Bruchus rufimanus* Boheman
XII.	Chrysomelidae ..	34.	*Aetheomorpha* sp.
		*35.	*Aulacophora foveicollis* (Lucas)
		*36.	*Chaetocnema concinnipennis* Baly
		37.	*Chrysochares asiaticus* Pallas ab. *ignitus* Jacob.
		*38.	*Chrysomela populi* L.
		*39.	*Plagiodera versicolora* (Laich.)
		40.	*Scelodonta* sp.

XIII.	Cerambycidae ..	41.	*Melanauster chinensis* Först.
		*42.	*Purpuricenus indus* Sem.
		*43.	*Xylotrechus smei* Cast. & Gory
XIV.	Curculionidae. ..	*44.	*Apion aeneum* Fab.
		45.	*Bagous* sp.
		46.	*Echinocnemus bipunctatus* Roelafs
		47.	*Platymycterus afghanistanicus* Voss
XV.	Scolytidae ..	48.	*Scolytus amygdali* Guer.
XVI.	Cetoniidae ..	*49.	*Gymnopleurus flagellatus* (Fab.)
		*50.	*Gymnopleurus miliaris* (Fab.)
		*51.	*Oxythyrea cinctella* (Sch.)
		52.	*Scarabaeus gangeticus* Cast.
		53.	*Scarabaeus sacer* (L.)
XVII.	Rutelidae ..	*54.	*Adoretus nitidus* Arr.
		*55.	*Adoretus versutus* Har.
		56.	*Anomala rufocuprea* Motsch.
		57.	*Anomala* sp.
XVIII.	Melolonthidae ..	58.	*Polyphylla* sp.
XIX.	Aphodidae ..	*59.	*Aphodius lividus* Ol.
		60.	*Rhyssemus germanus* L.
XX.	Copridae ..	61.	*Onthophagus* sp.

CICINDELIDAE

1. **Cicindela bigemina** Kl. var. **brevis** Horn

Horn, *Dtsch. ent. Z.*, p. 34 (1905)

I have about half a dozen specimens, one collected from a cotton field at Kundus on 9th July and the rest found on moist soil near canal water at Paghman on 29th June. The beetles were seen running about swiftly on cool moist soil.

This Cicindelid is known to occur in Bengal and the Punjab.

CARABIDAE

2. **Acupalpus (Egadroma) marginatus** Dej.

Dejean, *Spéc. gén. Col.*, 4: 427 (1829)

There are three specimens in the collection, all caught at light, one from Mazar-i-Sharif on 10th July and two from Kandahar on 23rd July.

This species has previously been recorded from the Mediterranean region, Middle Europe, Asia Minor, Caucasus, Caspian region, Turkestan, Madeira and Canary Islands.

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* These species are known to occur in India.

3. **Calosoma maderae** (Fab.)

Fabricius, *Syst. Ent.*, p. 237 (1775) (*Carabus*)

There are two specimens before me, one collected from Sihbaba on 23rd June and another taken at light at Ghazni on 19th July.

This species is previously known from South Europe, North Africa, Syria and Afghanistan.

4. **Hypolithus** sp.

Hypolithus Dejean, *Spéc. gén. Col.*, **4**: 166 (1829)

There is a single specimen of *Hypolithus* sp. caught at light at Mazar-i-Sharif on 10th July.

5. **Omophron rotandatus** Chd.

Chaudoir, *Bull. Soc. Nat. Moscou*, **25**: 101 (1852)

A single specimen of this species attracted to light at Kundus on 8th July is represented in the collection.

This species occurs in India (Baluchistan and United Provinces), Mesopotamia, Arabia, Palestine, Asia Minor, Persia, Turkestan, China, Caucasus, Armenia and Syria.

6. **Pheropsophus catoirei** (Dej.)

Dejean, *Spéc. gén. Col.*, **1**: 301 (1825) (*Brachinus*)

I have two specimens collected on the ground in a brinjal plot near Darra-i-Khaiber on 22nd June feeding on different kinds of caterpillars.

This carabid beetle has previously been recorded from India, Burma, Ceylon and Andaman Islands.

7. **Tachys** sp.

Tachys Stephens, *Ill. Brit. Ent.*, **2**: 2 & 4 (1828)

A small undetermined species of the cosmopolitan genus, *Tachys*, was collected in large numbers at light at Kundus on 8th July.

STAPHYLINIDAE

8. **Aleochara (Heterochara) glasunowi** Luze

Luze, *Horae Soc. ent. ross.*, **37**: 113 (1904)

Numerous adults of this beetle were found attracted to light at Kundus on 9th July. About 20 specimens are in the collection before me.

This species is known from Russian Turkestan also.

9. **Paederus fuscipes** Curt.

Curtis, *Brit. Ent.*, **3**: 108 (1823–40)

The beetle was taken at light at Haibak on 5th July.

It is widely distributed in India and Ceylon and also in the rest of the world except Americas. In the East it is particularly abundant in the paddy-fields, grass-lands, etc., specially after the monsoon.

10. **Philonthus** sp.

Philonthus Curtis, *Brit. Ent.*, **13**, tab 610 (1825); Stephens, *Ill. Brit. Ent.*, **5**: 226 (1825)

This genus is found throughout the world and is of very varied habits. Two specimens were taken at light at Kundus on 9th July.

COCCINELLIDAE

11. **Adalia decempunctata** L.

Linnaeus, *Syst. Nat.*, 10th ed.: 356 (1759)

In the Government garden at Istalif numerous adults of this Coccinellid were found feeding actively on the peach aphid, *Anuraphis* sp. on 26th July. Numerous empty pupal cases presumably of this Coccinellid were also found scattered on branches of peach which indicated an active breeding of the beetle in the near past. A few adults were also found on aphids infesting pear leaves at Tashqurghan (Mazar-i-Sharif province) on 10th July and a large number was collected feeding on apricot aphids at Kandahar, on 23rd July. Large number of aphid cast skins were seen in the curled leaves. This is probably one of the commonest aphid predators, widely distributed throughout the country.

This species is previously known from Europe, Asia, Japan (?) and North Africa.

12. **Adalia tetraspilota** Hope

Hope, in Gray's *Zool. Miscell.*, p. 31 (1831)

This species was found along with *Adalia decempunctata* L. feeding on aphids infesting pear at Tashqurghan in the province of Mazar-i-Sharif on the 10th July but it was rather rare. There are only two specimens in the collection before me.

It is previously known to occur in Nepal, Bukhara, and Afghanistan.

13. **Adonia variegata** Goeze

Goeze, *Ent. Beitr.*, **1**: 247 (1777)

There are 18 specimens before me taken on aphids infesting berseem at Bamian (5th July), on mites infesting sugar beet leaves at Baghlan (6th July), on apricot aphids at Kandahar (23rd July) and on wings at Tashqurghan (18th July).

Being fairly common throughout Afghanistan, this beetle seems to exercise considerable check on the multiplication of aphids and mites. At Baghlan, the adults were very abundant. At Kandahar the beetles were found within curled leaves of apricots infested some time ago by aphids, of which numerous cast skins were seen at the time of visit.

This Coccinellid is fairly common in Palaearctic region, middle Africa, India and China.

14. Aiolocaria mirabilis Motsch.

Motschulsky, *Reisen Amurl.*, 2: 245 (1860)

There are 16 specimens of this species before me taken on willow at Paghman on 24th and 29th June.

This beautiful large Coccinellid though quite common could not be found feeding on any insects on the plant during our first visit to Paghman. Aphids were absent. The only other insects found in association with these Coccinellids were the Chrysomelids, *Plagiodera versicolora* and *Chrysomela populi* in different stages of development. A collection of all the three species was brought and kept under observation in a cage. It was noticed that in several cases the Coccinellid adults attacked grubs of the Chrysomelid beetles and fed on them. This observation was confirmed during our second visit to Paghman and it appears that in nature the Chrysomelid grubs mentioned above form the normal host of this Coccinellid beetle. In India, Coccinellids are known to feed on larvae of *Monolepta*.

15. Coccinella conglobata L.

Linnaeus, *Syst. Nat.*, 10th ed.: 366 (1758)

This small brownish Coccinellid with beautiful light spots on elytra was collected in association with the aphids infesting willow at Paghman on 29th June and apricot at Kandahar on 23rd July. No aphids were found at the time of visit but their cast skins were quite abundant. The beetle is not very common: there is one specimen before me from Paghman and two from Kandahar.

This species is restricted to the Palaearctic region.

A few specimens, rather pale and without markings, which may be the immature forms of the above or a variety of *Coccinella conglobata* L. were found among aphid cast skins on apricot at Kandahar on 23rd July.

16. Coccinella undecem-punctata L. var. menetriesi Muls.

Mulsant, *Spec. Trim. Securipalp.*, p. 104 (1850)

This species, so common in India, was rather rare in Afghanistan. The beetle and its grub known to actively predate on several species of Aphids, were found feeding on mites infesting sugar beet leaves at Baghlan on 6th July, and on some aphids on paddy near Paghman on 18th July.

It is a cosmopolitan species and is common in Europe, North Africa, Asia and North America.

17. Coccinella septempunctata L.

Linnaeus, *Syst. Nat.*, 10th ed.: 365 (1758)

In spite of the prevalence of many species of Aphididae in the country, this predator was extremely rare. A few adults were observed feeding on mites nfesting sugar beet leaves at Baghlan on 6th July.

This highly beneficial species originally recorded from the Palaearctic region is widely distributed throughout India, and is previously recorded from Afghanistan also.

18. **Epilachna dodecastigma** Muls.

Mulsant, *Spec. Trim. Securipalp.*, p. 789 (1850)

There are 15 adults and many grubs and pupae of this species before me. The adults were taken from a cotton field and also captured at light at Kunduz on the 8th July, and collected from a berseem field at Bamian on the 5th July. At Dakka (22nd June) and Baghlan (6th July) no adults or eggs were noticed at the time of visit but large number of grubs skeletonising lower surface of brinjal and melon leaves and pupae were found. Several adults were reared from the grubs collected from the latter two places.

Full grown grubs pupating on the 6th July emerged as adults on 13th and 14th July, *i.e.*, after a pupal period of about a week. The beetle seems to be a minor pest of melon and brinjal in the country.

It has previously been recorded from Tasmania, Java, Sumatra and India. It is often a serious sporadic pest on brinjal and bitter gourd in India.

19. **Exochomus flavipes** Thunbg. ab. **nigripennis** Er.

Erich, *Archiv. Naturgesch.*, 9: 267 (1843)

There is a single specimen before me collected from *Citrus* sp. near Peshawar on 19th June.

This Coccinellid occurs in Palaearctic and Aethiopian regions.

20. **Halyzia tschitcherini** Sem.

Semenow, *Horae Soc. ent. ross.*, **29**: 142 (1895)

This species has already been recorded from Afghanistan. A specimen of this species was found at Paghman on 29th June.

21. **Halyzia** sp. (prox. **16-guttata** L.)

In association with another Coccinellid, *Coccinella conglobata*, this beetle was found in very limited numbers on aphids infesting willow, at Paghman on 29th June.

The genus *Halyzia* is widely distributed in Europe, Asia Minor, Caucasus and Siberia.

22. **Scymnus** sp.

Scymnus Kugelann, *Noves Magazine Liebh. Ent.*, **1** (5): 545 (1794)

While examining a serious infestation of *Hyalopterus* sp. on apricot in the British Legation Garden, Kabul, on 28th June, several tiny grubs, fluffy in appearance above and greenish below, were seen among aphids. These were collected and reared on aphids. Five of these grubs completed development and pupated on 30th June On 13th July, *i.e*, after a pupal period of 13 days tiny

adults emerged. This seems to be an interesting species not represented in the British Museum and may be new.

DRYOPIDAE

23. **Dryops jeanneli** Boll.

Bollow, *Mitt. München. ent. Ges.*, **28** (1938)

Four specimens of this small beetle were found in the light trap catch at Kundus on 9th July. This species is previously recorded from Turkistan.

HETEROCERIDAE

24. **Heterocerus (Litorimus) obliteratus** Kiesw.

Kiesenwetter, in Germar's *Zeitschr. f. d. Entomologie, Leipzig*, **4**: 219 (1943)

Large numbers of this species were attracted to light and caught at Kundus on 9th July and at Kandahar on 23rd July. There are about two dozen specimens before me.

This species has previously been recorded from Asia Minor, Mesopotamia and Caucasus.

25. **Heterocerus** sp.

Heterocerus Fabricius, *Ent. Syst.*, **1**: 262 (1792)

Undetermined specimens of *Heterocerus* sp. were found in large numbers in the light trap catch at Kundus on 9th July.

BUPRESTIDAE

26. **Sphenoptera lafertei** Thoms.

Thomson, *Typi Bupr. Mus. Thoms.*, p. 65 (1878)

A number of peach trees were found attacked by larvae of this species boring into the main stem and branches at Kandahar on 23rd July. Some affected branches were collected and brought for rearing the larvae to the adult stage.

This species has so far been recorded from North-West India only.

ELATERIDAE

27. **Agrypnus** sp.

Agrypnus Eschscholtz., in Thon, *Ent. Arch.*, **2** (1): 32 (1829)

This large undetermined Elaterid beetle was collected from apricot tree at Paghman on 29th July.

This genus has a world-wide distribution.

MELOIDAE

28. **Epicauta erythrocephala** Pall.

Pallas, *Reise russ. Reich.*, **1**: 14 (1876)

I have 31 specimens of the beetle taken on sugar beet leaves at Baghlan on 6th July. The adults were present in large numbers doing serious damage by

defoliating the beet crop. The damage was so serious that labourers had been specially employed for handpicking them. Enquiries showed that these beetles were active in the morning upto ten o'clock and again in the afternoon from four to seven o'clock. It is not known where the immature stages of the beetle occur. Sugar beet cultivation had been recently introduced in this area by the Afghan Government and finding as high as 18% sugar in the roots cultivated here, the Government is giving great impetus to extend its cultivation. The manner in which this beetle pest was said to be increasing, suggests that unless it is properly controlled it may seriously hamper the extension of sugar beet cultivation in the area.

Its range of distribution is in South Europe, Ural, Turkistan, Siberia and Southern Russia.

29. **Mylabris damascena** Rch.

Reiche, *Ann. Soc. ent. Fr.*, (4) 5: 634 (1865)

Adults of this species were abundant on willow leaves and mustard flowers at But-i-Khak near Kabul on 23rd June. The damage caused was quite significant. There are seven specimens in the collection before me.

This Meloid is so far known from Syria only.

30. **Mylabris phalerata** Pall.

Pallas, Icon. *Ins.*, p. 78 (1781)

In association with *Mylabris damascena*, a few adults of *M. phalerata* were also seen visiting mustard flowers at But-i-Khak on 23rd June. There is only one specimen of this species before me.

This species has previously been recorded from India and China.

31. **Mylabris** sp.

Mylabris Fabricius, *Syst. Ent.*, p. 261 (1775)

The adults of another species of *Mylabris* similar in habits to *Mylabris damascena* and *M. phalerata* but much smaller in size were seen on mustard flowers at But-i-Khak on 23rd June.

ANTHICIDAE

32. **Anthicus crinitus** Laf. var. **communimacula** Frm.

Fairmaire, *Ann. Soc. ent. Belg.*, **40**: 47 (1896)

Out of the numerous specimens of this species attracted to light at Kundus on 9th July thirteen are present in the collection.

This variety has so far been known from India only.

BRUCHIDAE

33. **Bruchus rufimanus** Boheman

Boheman, in Schonherr's *Gen. Curc.*, **1**: 58 (1833)

These specimens were found in the collection of Mr. H. Into of Agricultural College, Tokyo, Japan, who was then teaching Entomology in School of Agriculture, Kabul.

This bruchid is widely distributed having been recorded from Central and Southern Europe, Western Asia, Africa, America, Cuba and Canarese Islands.

CHRYSOMELIDAE

34. **Aetheomorpha** sp.

Aetheomorpha Lacordaire, *Mem. Soc. Sci. Liège*, **5**: 311 (1848)

This is a very rare species, only a couple of adults having been observed on leaves of sugar beet at Baghlan on 6th July. It is a brownish beetle somewhat larger than *Aulacophora foveicollis* and bears four prominent black dots on each elytron in two rows, those in the hind row are coalesced together.

This genus originally described from Africa is represented in the fauna of India and Australia.

35. **Aulacophora foveicollis** (Lucas)

Lucas, *Explor. Sci. d' Alger. Zool.*, II. *Insects*, p. 542 (1849) (*Galaruca*)

Adults were collected in large numbers feeding on leaves of pumpkin creepers at Dakka (Jalalabad valley) on 22nd June and Kandahar on 21st July.

This is a well-known species occurring throughout India as a pest of almost all cucurbitaceous creepers. The grubs feed on roots and stems and the adults on leaves. Outside India it is known to occur widely in South Europe, Algeria, Egypt, Cyprus, Iran and Andaman Islands.

36. **Chaetocnema concinnipennis** Baly

Baly, *Trans. R. ent. Soc. Lond.*, p. 170 (1877)

It is a more or less common species, a large number having been captured at light at Kundus on 8th July. A few adults of probably the same species were found on apple leaves at Kandahar on 23rd July.

This species is quite common in India, having been recorded from Bihar, Bengal, Sikkim, Assam and South India. It is also known from Ceylon.

It is a sporadic minor pest of paddy seedlings.

37. **Chrysochares asiaticus** Pallas ab. **ignitus** Jacobs.

Jacobsen, *Horae Soc. ent. ross.*, **28**: 158 (1893–94)

This large shining green beetle was extremely abundant defoliating seriously *Ipomoea* sp. a plant growing wild near Doab-i-Mekhzarin on 14th July. No

plant of economic importance was found damaged. A strong petromax lamp set up at night did not attract the beetle. A copulating pair found in the evening was caged but did not lay eggs.

This Chrysomelid is known from Southern U.S.S.R. (Caucasia and Armenia).

38. **Chrysomela populi** L.

Linnaeus, *Syst. Nat.*, 10th ed.: 370 (1758)

This is probably as common as *Plagiodera versicolora* in association with which it occurs in the environs of Kabul. All stages were collected from Paghman on willow (24th and 29th July).

Fairly large yellow eggs are laid in clusters on leaves. The grubs skeletonise the leaves, which consequently dry and fall off. The rather large-sized adults are voracious feeders cutting the leaves along their edges and devouring them, and when present in large numbers this beetle is as bad as *Plagiodera.* Half developed grubs collected on 29th June pupated on 5th July and the adult beetles emerged on 10th July. The pupal period is thus about 5 days in summer.

It was originally described from Europe and later on found to occur in North Africa, North and West Asia, China and Japan. In India is has been reported from Hazara District (Punjab), Ranikhet (Kumaon Hills) and Assam.

39. **Plagiodera versicolora** (Laich.)

Laicharting, *Verz. Tyrol. Käfer.*, **1**: 148 (1781)

Distribution.—It is one of the commonest Chrysomelids found in several gardens in the environs of Kabul. All stages were collected from Gul Bagh (25th June) on willow, British Legation Garden (28th June) on ash and Paghman (24th June and 17th July) on willow. Beetles were also found in a light trap catch at Kundus near Khanabad (8th July).

Life-history—Bright yellow eggs are laid on leaves. They are glued endwise in clusters of ten to fifteen. The young grubs on hatching remain gregarious for a few days but scatter away on the plant later on. They skeletonise the leaves which consequently dry and fall off. Pupation takes place on leaves, the full-grown grub fixing itself firmly on the leaf surface before pupation. The black shiny adults copulate and lay eggs on leaves.

It seems to be a fairly serious pest doing considerable damage to willow and ash.

The grubs were being predated upon by adults of the large Coccinellid, *Aiolocaria mirabulis* Motsch.

At British Legation it was stated that the pest had been successfully controlled by lead arsenate spray.

This species, described originally from Europe, has a wide distribution in Europe, North Africa, Siberia and Japan. In India it has so far been recorded

from the Punjab, North-West Frontier Province, Baluchistan and the United Provinces on willow leaves. In Baluchistan it is a minor pest of grape vines. It is already recorded from Afghanistan (Scheibe, 1937).

40. **Scelodonta** sp.

Scelodonta Westwood, *Proc. Zool. Soc. Lond.*, p. 129 (1837)

There is a single specimen taken from poplar leaf at Gul Bagh near Kabul on 25th June.

Another species, *S. strigicollis* Motsch., is a pest of grape vine in India specially in North-West Frontier Province.

Members of the genus are known to occur in Philippines, Malayan Islands, China, India and Africa.

CERAMBYCIDAE

41. **Melanauster chinensis** Forster

Forster, *Nov. Spec. Ins.*, p. 39 (1771)

A few specimens of this species said to have been collected locally were found in the collection of Mr. Hide Into of Agricultural College, Tokyo, Japan, who was at the time of our visit teaching Entomology to students of Agriculture in Kabul.

42. **Purpuricenus indus** Sem.

Semenow, *Rev. Russe Ent.*, 7: 139 (1888)

This beautiful Cerymbacid was caught on wings near Darra-i-Khail on 22nd June.

It has previously been recorded from Kashmir.

43. **Xylotrechus smei** Cast. & Gory

Castelnau & Gory, *Monogr. des Clytus*, p. 37 (1835)

One adult of this species was collected from the underside of the bark of apple tree at Kabul on 3rd August.

This beetle is widely distributed in India. It is a borer of dry wood.

CURCULIONIDAE

44. **Apion aeneum** Fab.

Fabricius, *Syst. Ent.*, p. 131 (1775)

The grubs of this weevil seem to be a serious pest of hollyhock, an ornamental plant finding great favour among flower growers in the country. Although eggs of the weevil were not discovered it seems they are laid near the roots of the plant. Young grubs in different stages of development were found just underneath the soil feeding on the roots of hollyhock at Paghman on 29th June and 29th July. In some cases as many as one dozen grubs were found under each plant. Like other root-boring insects the damage by the grubs of this weevil

is serious because the entire plant dries up after a few days. The full grown grubs brought in the laboratory pupated under soil but died before completing development.

This Curculionid is previously recorded from Europe, Algiers and Asia.

45. **Bagous** sp.

Bagous Germain, *Magazin d. Entomologie*, **2**: 340 (1817)

There are about a dozen specimens of this weevil before me, one taken on berseem leaf at Bamian on 4th July and the rest collected at light from Kundus on 9th July. The species is reported to be unrepresented in the British Museum and may be new.

46. **Echinocnemus bipunctatus** Roelafs

Roelafs, *Ann. Soc. ent. Belg.*, **17**: 123 (1874)

Specimens of this species collected from Afghanistan were found in the collection of Mr. Hide Int'o, Lecturer in Entomology in Kabul. No data about food plants were available.

47. **Platymycterus afghanistanicus** Voss

Voss, *Senckenbergiana.*, **19**: 248 (1937)

There are before me 26 specimens in all; one collected near But-i-Khak on 23rd June, 22 taken feeding on hollyhock and rose leaves at Paghman on 24th and 29th June, and 3 taken from poplar at Kabul on 30th June.

Although collected from three places only, this weevil seems to be fairly common. At Paghman it was so seriously eating away flower petals and leaves that it may be mentioned as a pest of rose and hollyhock. Several copulating pairs were collected which laid white translucent eggs in captivity. It was however not possible to rear the grubs which hatched out of the eggs. The species is reported to be new to the British Museum collection.

It is hitherto known from Afghanistan only.

SCOLYTIDAE

48. **Scolytus amygdali** Guer.

Guerin, *Bull. Soc. ent. Fr.*, **27**: 46 (1847)

One adult of this species was found under the bark of apple tree at Kabul on 3rd August. It is a European species.

Commonly known as shot hole borer, it is a pest of almond trees in Spain and Palestine, of plums and almonds in Cyprus, of peaches and plums in Bulgaria, and of apricot, almond, cherry, peach, nectarine, apple, plum and quince in Baluchistan.

CETONIIDAE

49. **Gymnopleurus flagellatus** (Fab.)

Fabricius, *Mant. Ins.*, p. 17 (1787) (*Scarabaeus*)

I have one adult specimen of this species before me, collected from cattle dung at Amar Khail on 18th July.

This species has been previously recorded from Spain, Morocco, South France, Turkistan, Caucasus, Palestine, Persia, Afghanistan, Kashmir, Baluchistan (Gwal Forest 6,000 ft.) and Waziristan.

50. **Gymnopleurus miliaris** (Fab.)

Febricius, *Syst. Ent.*, p. 817 (1775) (*Scarabaeus*)

The beetles were collected from a cotton field at Kabul on 26th June and at light at Mazar-i-Sharif on 10th July. There are in all seven specimens before me.

It is widely distributed in India having been recorded from N.W.F.P., Kashmir, Central Provinces, United Provinces, Orissa, Bengal, Bhutan, Bombay, South India and also from Ceylon.

51. **Oxythyrea cinctella** (Sch.)

Schaum, *Analecta Entomologica*, p. 38 (1841) (*Cetonia*)

Adult beetles of this species were found feeding on flowers of rose at Paghman on 29th June and on flowers of Dahlia at Mazar-i-Sharif on 11th July. There are seven specimens in the collection, but the beetle was fairly common and was causing considerable damage to flowers of these plants.

This species was originally recorded from Baluchistan (Nushki and Quetta) and is already known from Afghanistan.

52. **Scarabaeus gangeticus** Cast.

Castelnau, *Hist. Nat. Ins. Col.*, **2**: 64 (1840)

There are four specimens of this species before me, one collected from Chardih on 4th July and three from Kundus on 8th July, all found on the ground.

This is well represented in Palaearctic and Aethopian regions being known from Abyssinia, East Africa, Somaliland, West Africa, Uganda, Transvaal, Rhodesia, Arabia, Persia, India (Bengal, the Punjab, South India) and Ceylon.

53. **Scarabaeus sacer** (L.)

Linnaeus, *Syst. Nat.*, 10th ed.: 347 (1758) (*Ateuchus*)

Two specimens of this species were collected from dung near Kalat-i-Ghilzai on 21st July.

This species extends its range from the Mediterranean to India. It is one of the commonest dung-roller, and is the sacred Scarabaeus depicted by the Egyptians in the hieroglyphics. It is previously recorded from Afghanistan.

RUTELIDAE

54. **Adoretus nitidus** Arr.

Arrow, *Ann. Mag. nat. Hist.*, (8) **13**: 599 (1914)

This seems to be a widely distributed beetle in Afghanistan, a number of them having been captured at light near Aibak on 5th July, Kundus on 8th July, Mazar-i-Sharif on 10th July, Doaba Mekhzarin on 14th July and Ghazni on 19th July. All the specimens before me were taken at petromax light to which the adults were strongly attracted.

It has previously been known from Burma.

55. **Adoretus versutus** Har.

Harold, *Coleopterologische Hefte*, **5**: 124 (1869)

Along with *Adoretus nitidus*, one specimen of *A. versutus* was also found attracted to light at Doaba Mekhzarin on 14th July.

This species is widely distributed in India. Outside India it is known to occur in Ceylon, Malaya Peninsula, Java, Fiji, Samoa, Mauritius, Seychelles and Andamans.

56. **Anomala rufocuprea** Motsch.

Motschulsky, *Etud. Ent.*, **19**: 14 (1860)

This species said to have been collected locally was represented in the collection of Mr. Hide Into, Lecturer in Entomology in Kabul.

It has so far been known to occur in Japan only.

57. **Anomala** sp.

Anomala Samouelle, The Entomologist's Useful Compendium, p. 191 (1819)

Some unidentified specimens of *Anomala* were collected flying about after sunset at Bamian on 4th July.

MELOLONTHIDAE

58. **Polyphylla** sp.

Polyphylla Harris, Rep. Ins. Massach., p. 30 (1842)

This large dirty-brown Melolonthid over an inch long and about half an inch broad was extremely common and often found swarming in large numbers soon after dusk in semi-mature wheat fields. They would fly a short distance and then settle on green wheat ears and nibble them. A number of them were collected with a hand net as well as by setting up light traps at Aibak on 5th July, Doaba Mekhzarin on 14th July and Ghazni on 19th July. The species is reported to be not represented in British Museum Collection.

This genus has a world-wide distribution, being known from Europe, Asia, Africa and the Americas.

APHODIDAE

59. **Aphodius lividus** Ol.

Olivier, *Entomologie*, 1, 3, p. 86 (1789)

This cosmopolitan species as well as another unidentified species of *Aphodius* were found among the insects taken at light at Kundus on 8th July and Kandahar on 23rd July.

60. **Rhyssemus germanus** L.

Linnaeus, *Syst. Nat.*, 12th ed., 1, 2: 566 (1767)

This small aphodid beetle was very common at Kundus and a large number of adults were taken at light on 8th July.

It has so far been recorded from Europe, Caucasus, Asia Minor, North Abyssinia, Afghanistan and India.

COPRIDAE

61. **Onthophagus** sp.

Onthophagus Latreille, *Hist. Nat. Crust. et. Ins.*, p. 141 (1802)

I have two specimens of an unidentified species of *Onthophagus* before me collected from cattle dung at Ghazni on the 18th July. The genus has world-wide distribution. Several species of the genus are previously recorded from Afghanistan.

LIST OF SPECIES OF COLEOPTERA COLLECTED BY PREVIOUS WORKERS FROM AFGHANISTAN

I. *Collection made by Aitchison* (1885)

1. *Adesmia fagergreeni* Baudi.
2. *Adesmia panderi* Fischer.
3. *Adesmia sodalis* Wat.
4. *Adoretus* sp.
5. *Agapanthia nigriventris* Wat.
6. *Agelastica alni* Fabr.?
7. *Apalus plagiatus* Wat.
8. *Blaps felix* Wat.
9. *Blaps Ominosa* Menetr.
10. *Blaps pruinosa* Fald.
11. *Blaps punctostriata* Solier.
12. *Blaps tridentata* Wat.
13. *Cantharis conspicua* Wat.
14. *Cantharis glabricollis* Wat.
15. *Cantharis laeta* Wat.
16. *Capnodis miliaris* Klug.
17. *Capnodis tenebrionis* Linn.
18. *Cetonia armeniaca* Menetr.
19. *Cetonia floralis* Fabr.
20. *Cetonia* sp.
21. *Coccinella septempunctata* Linn.
22. *Cybister tripunctatus* Oliv.
23. *Diesia cortifera* Wat.
24. *Dila laevicollis* Gebler.
25. *Dioctes lehmanni* Menetr.
26. *Homalocopris toolus* Fischer.
27. *Hydrophilus caraboides* Linn.
28. *Julodis euphractica* Cast & Gory.
29. *Julodis laevicostata* Gory.
30. *Julodis variolaris* Pall.

31. *Labidostomis humeralis* Schneider.
32. *Lachnosterna* sp.
33. *Meloe tuccius* Rossi.
34. *Meloe variegatus* Donov.
35. *Mylabris frolovii* Germ.
36. *Mylabris klugii* Redt.
37. *Mylabris maculata* Oliv.
38. *Mylabris variabilis* Pallas.
39. *Ocnera gracilis* Wat.
40. *Ocnera gomorrhana* Reiche.
41. *Omophlus lepturoides* Fabr.
42. *Oxythyrea stictica* Linn.
43. *Plocaederus scapularis* Fischer.
44. *Prosodes diversa* Wat.
45. *Scarabaeus sacer* Linn.
46. *Spyrathus politus* Wat.
47. *Sympiezocemis kessleri* Solsky.
48. *Trigonoscelis longipes* Wat.
49. *Trigonoscelis nodosa* Fischer.
50. *Tropinota squalida* Linn.

II. *L. von Heydon's Collection* (1894)

1. *Acinopus pischardi* Ganglb.
2. *Acinppus piochardi* Gangl (*Striolatus* Heys. non Zoubk).
3. *Adekicera trustus* Krtz.
4. *Adesmia panderi* Fisch.
5. *Aeolus cruciatus* Cand. (*ballioni* Heyd.)
6. *Aeolus Rossie* Germ.
7. *Agapanthia detrita* Krtz.
8. *Amara aenea* Deg (*trivralis* Gyll)
9. *Amara famelica* Zmrm.
10. *Amphicoma analis* Sols.
11. *Amphicoma kuschakewitschi* Ball.
12. *Anthicus flavisternus* Mars.
13. *Anthicus flavisternus* Mars auch Alai.
14. *Anthicus formicarus* Goeze (*quisquilius* Thoms)
15. *Anthocomus dux* Ablle.
16. *Anthrenus pimpinellae* F.
17. *Anthrenus picturatus* Sols.
18. *Anthodromius turkestanicus* Heyd.
19. *Aphodius lunifer* Sols.
20. *Aphodius quadriguttatus*
21. *Apion merale* Faust.
22. *Apion uniseriatum* Faust.
23. *Aristus semicylindricus* Pioch.
24. *Attagenus pictus* Ball.
25. *Blechrus parallelus* Ball.
26. *Blechrus plagiatus* Dft.
27. *Blechrus exilis* Schaum (*minutus* Mot.)
28. *Bothynoderes melancholicus* Mer. Var. *innocuus* Faust.
29. *Brachynus immaculicornis* Dej. var. *ejaculans* Fisch.
30. *Brachypterus quadratus* Stm.
31. *Bulaea Lichateschovi* Hunnel.
32. *Cabirus pusillus* Men.
33. *Capnisa glabra* Fisch.
34. *Capnodis tenebricosa* Hbst.
35. *Cardiophorus picticolles* Krtz.
36. *Cardiophorus* n.sp. *propecrux* Cand.
37. *Cassida undecimnotata* Gebl.
38. *Cetonia marginieollis* Ball.
39. *Centrocnemis mollis* Krtz.
40. *Chaetocnema hortensis* Fourcr.
41. *Chloebius steveni* Bohem.
42. *Chromonstus confluens* Fabr.
43. *Chrysomela cerealis* L. var. *alternaus* Panz (*megerlu* F.)
44. *Chrysomela circumducta* Men.
45. *Cicindela decempunctata* Men. var. *nigra* Dokht.
46. *Cicindela turkestanica* Ball. V. *maracandensis* Solsky.
47. *Coccinella septempunctata* L.
48. *Corticaria illaesa* Mhm.
49. *Corymbites atratus* Ballion.
50. *Cymindis Andreae* Men.
51. *Dasytiscus* (*Chaetomalachius*-olim)
52. *Dasytiscus dasytoides* Krtz.
53. *Dermestes coronatus* Stev.
54. *Dermestes Vulpinus* F.

55. *Dichillus brunneus* Krtz.
56. *Dichillus seminitidus* Solksy.
57. *Diorhabda bersica* Fald.
58. *Drasterius bimaculatus* Rossi.
59. *Ebaeus tripictus* Ablle.
60. *Epicometis hirta* Poda.
61. *Euderces (cleroelytus) semirufus* Krtz.
62. *Eulobonyx turkestanicus* Krtz.
63. *Eutagenia turcomana* Reitt.
64. *Gnathosia nasuta* Men.
65. *Gynandrophthalma viridis* Krtz.
66. *Harpalus affinis* Ball.
67. *Heterophylus pygmalus* Fisch.
68. *Hippodamia tredecimpunctata* Var *Xanthoptera* Muls.
69. *Hispella atra* L.
70. *Hister falsus* sols, seltene Art.
71. *Labidostomis bipunctata* Mhm.
72. *Laena dilutella* Solsky.
73. *Lasiostola piligera* Krtz.
74. *Lena nekabioa* L.
75. *Liparus seriato punctatus* Heyd.
76. *Lithophilus haemorrhous* Solaky.
77. *Lixus algirus* L.
78. *Lixus strangulatus* Faust.
79. *Lixus tschemkenticus* Faust.
80. *Lyctus (xylotrogus) brunneus* Stph.
81. *Malachius imperials* Moraw. (*rubromarginatus* Reitv)
82. *Mecaspis Darwini* Faust.
83. *Melanotus persicus* Menetr.
84. *Melanotus validus* Schway
85. *Melolontha afflicta* Ball.
86. *Mesagroecus terrestris* Faust.
87. *Metabletus exclamationis* Men.
88. *Metabletus parallelus* Ballion.
89. *Mordellistena stenidea* Muls.
90. *Ocyusa defecta* Rey.
91. *Omalium caesum* Grav.
92. *Oxythyrea cinctella* Schaum.
93. *Pachnephorus tessellatus* Dft.
94. *Pachnephorus tessellatus* Var. *Sabulosus* Gebl.
95. *Pachybrachys instabibs* Woc.
96. *Pachyscelis Pygmaea* Men.
97. *Pachytychius (Barytychius) illectus* Faust.
98. *Pangus diversopunctatus* Sols.
99. *Pangus intermittens* Sols.
100. *Pangus namanganensis* Heyden.
101. *Perieges bardus* Bohem. var. *minor* Faust.
102. *Phytoecia cinerascens* Krtz.
103. *Plocaederus scapularis* Fisch.
104. *Poecilus liosomus* Chaud.
105. *Polydrusus Dohrni* Faust.
106. *Psammodius variolosus* Kolery.
107. *Pseudotaphoxenus Juvencus* Ball.
108. *Rhizotrogus glabricollis* Reitt (*tekkensis* Brenske)
109. *Rhyncolus truncorum* Germ.
110. *Rhyssemodes alutacens* Reitt.
111. *Saprinus lateralis* Mot.
112. *Scarites eurytus* Fisch.
113. *Scleron carinatum* Baudi.
114. *Scleropatrum striatogranulatum* Reitt.
115. *Scolytus multistriatus* Marsh.
116. *Serica orientalis* Mot.
117. *Sitona crinita* Hbst.
118. *Smicronyx robustus* Faust.
119. *Stalagmoptera atriata* Krtz.
120. *Stenosis sulcicollis* Men.
121. *Syncalypta paleata* Er.
122. *Tachyporusnitidulus* F. (*brunneus* F.)
123. *Tanyproetus opacus* Ball.
124. *Trechus quadristriatus* Schrk.
125. *Trogoderma ornata* Sols.
126. *Xylinophorus prodromus* Faust.
127. *Zabrus gibbosus* Zmrm.

III. *Collection made by Scheibe* (1935)

1. *Adalia tetraspilota* Hope.
2. *Adoretus* (*Lepadoretus*) *horni* Boucomont.
3. *Adoretus nigrifrons* Stev.
4. *Adoretus* (*Lepadoretus*) *nuristanicus*
5. *Aeolesthes indicola* Bat.
6. *Agonum ladakense* Bat.
7. *Aiolocaria hexaspilota* Hope
8. *Amaladera* sp.
9. *Anthaxia scheibei* Thery.
10. *Apatophysis kashmiriana* Sem.
11. *Blaps caraboides* All.
12. *Blitophaga turkestanica* Ball:
13. *Bloramix afghanicus* Schuster.
14. *Bostrychus capucinus* L.
15. *Brahmina cribricollis* Redt.
16. *Brahmina* (*Rhizocololax*) *dilaticollis* Ball.
17. *Calosoma maderæ dungaricum* Gebl.
18. *Calosoma maderae indicum* Hope.
19. *Calosoma sycophanla himalayanum* Gestrs.
20. *Cantharis biocellata* Fairm.
21. *Carabus scheibi* Eidam.
22. *Cardiophorus hauseri* Schwarz.
23. *Chrysomela coerulans subfastuosa* Motsch.
24. *Cicindela chloris* Hope.
25. *Cionus schultzei nuristanus* Voss.
26. *Clytra læviuscula afghanica* Reineck.
27. *Compsolacon aequalis* Cand.
28. *Ditomus semicylindricus* Geln.
29. *Dorcus rotundo-punctatus* Nagel.
30. *Eulobonyx scheibei* Blair.
31. *Geotrupes jakovlewi* Sem.
32. *Gonocephalum simulatrix* Fairm.
33. *Gymnopleurus coriarius* Herbst.
34. *Haltica parvida* Ws.
35. *Haltica turcmenica* Ws.
36. *Halyzia tschitehrini* Sem.
37. *Hister* (*Atholus*) *ixion* Lew.
38. *Hoplia scheibei* n.sp.
39. *Hoplosternus* (*Melolontha*) *insignis* Sem.
40. *Hydrous indicus* Bedel.
41. *Ischyromus marquardti* Breit.
42. *Julodis euphratica* C.G.
43. *Julodis faldermanni* Mann.
44. *Labidostoma nurestanica* Reineck.
45. *Laccobius sp. near rotundatus* Regimb.
46. *Lagria indicola* Bates.
47. *Leptura rubriola* Bates.
48. *Lycostomus afghan* Kleine.
49. *Lytta clemitidis* Pall.
50. *Macrotoma crenata* Fab.
51. *Malachius coeruleoscutatus* Fairm.
52. *Meganoxia* (*Cyphonotus* ?) *pauper* Brenske.
53. *Melasoma populi* L.
54. *Melasoma saliceti afghanica* Reineck.
55. *Metabletus fuscomalatus* Motsch.
56. *Mylabris cincta* Oil.
57. *Mylabris colligata* Redtle.
58. *Mylabris macilenta* Mars.
59. *Mylabris quadrisignata* Fisch.
60. *Mylabris variabilis* Pall.
61. *Myllocerops afghanistanensis* Voss.
62. *Onthophagus atramentarius* Men.
63. *Onthophagus expansicornis* Bates.
64. *Onthophagus gibbosus Weisei* Reit.
65. *Opatroides punctulatus* Br.
66. *Oryctes masicornis grypus* Illig.
67. *Pentadon bidens* Pall.
68. *Phaedoretus coaemptus* Men.
69. *Phytoecia circumdata* Kr.
70. *Pimelia* (*Chaetotoma*) *horni* Schuster.
71. *Plagiodera versicolora* Laich.
72. *Platyscelis margellanica* Kr.

73. *Prionus elliotti* Gab.
74. *Prosodes afghanica* Schuster.
75. *Prosodes schcibi* Schuster.
76. *Protaetia impavida* Jans.
77. *Protaetia neglecta* Hope.
78. *Purpuricenus nuristanicus* Heyrovsky.
79. *Rhantus punctatus* Fourer.
80. *Rhyssemus germanus* L.
81. *Saprinus semistriatus* Scriba.
82. *Semiadalia andrewesi* Sic.
83. *Silpha obscura* L.
84. *Syachus afghanicus* Schuster.
85. *Synharmonia conglobata* L.
86. *Themus nurestanus* Hieker.

Height above sea level of some important localities in Afghanistan

Aibak	3,511 feet	Kalati Ghilzai	5,543 feet
Baghlan	1,300 ,,	Kandahar	3,425 ,,
Doabi Mekhzarin	3,000 ,,	Khanabad	1,270 ,,
Ghazni	7,279 ,,	Kundus	1,100 ,,
Istalif	6,000 ,,	Mazari Sharif	1,237 ,,
Jalalabad	2,050 ,,	Paghman	7,300 ,,
Kabul	5,850 ,,	Tashqurghan	1,490 ,,

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ON A FOSSIL WEEVIL FROM NAGPUR, INDIA

By M. S. MANI

Assistant Professor of Zoology, St. John's College, Agra

The Inter-Trappean Tertiary deposits of the Lower Trap rocks at Takli near Nagpur, discovered by the pioneer naturalist and missionary Stephen Hislop[1] nearly a century ago, have yielded fossil remains of plants, terrestrial insects and Crustacea and Mollusca characteristic of shallow fresh waters. The insect remains belong wholly to the order Coleoptera and comprise mostly fragments of single elytra. In 1860, Murray[2] studied these fossil beetles and published brief notes on thirteen specimens: eight of Curculionidæ and five of Buprestidæ, but he named only one Curculionid *Meristos hislopi* Murray and one Buprestid *Lomatus hunteri* Murray.

In a small batch of the plant remains from the Hislop-Hunter collection from Takli, borrowed from the British Museum by Prof. Birbal Sahni, Department of Botany, Lucknow University, I found a well preserved fossil remain of an undescribed Curculionid, which is described below under the name *Palæotanymecides hislopi*, gen. *et* sp. nov.

It is represented by a hollow imprint of the upper surface of almost the complete right elytron in an irregular piece of argillaceous rock about 30 mm. long, 25 mm. thick and 15 mm. broad, on which is also found a small fragment of some plant fossil on one side. It does not agree with any of the fossil remains described and figured by Murray (*loc. cit.*) from the same locality or with other Curculionid fossils known so far from the world. Its general shape, comparative flatness[3] and the longitudinal parallel striae on it are suggestive of the elytra of Buprestidae or of Harpaline Carabidae (Adephaga) but it is easily distinguished by the presence of the characteristic punctures in the striae and by the absence of the characteristically reflexed outer margin with rows of setigerous punctures.[4] Its Curculionid affinity is clearly indicated by the pronouncedly

[1] Hislop, S., 1860, *Quart. J. geol. Soc. London*, **16**: 154–166, pl. v–x. *Vide* also in this connection Medlicott, H. B., and Blanford, W. T., 1879, A Manual of the Geology of India, Calcutta, p. 311.

[2] Murray, A., 1860, *Quart. J. geol. Soc. London*, **16**: 182–185, 189, pl. x, figs. 66–70.

[3] Although there are some obscure irregular transverse cracks, the specimen does not show any evidence of having been crushed or otherwise deformed during fossilisation. The flatness of the elytron is thus preserved in the natural state.

[4] In view of the fact that fossil Coleoptera are mostly preserved as fragments of elytra, the taxonomic importance of a knowledge of the elytra of Recent forms for purposes of comparison is apparent. It is however extraordinary how little is known regarding the macro- and microstructure of the elytra. Except for some scattered papers and brief accounts in taxonomic descriptions of species, the only comprehensive work perhaps is "Monographie de l'élytre des Coléoptéres adéphages" by Jeanel (Jeanel, R., 1925, *Arch. zool. exptl. et gén.*, pp. 1–84), though dealing with a part of the order.

deflexed declivity and by the punctate and narrow impressed lines (striae). The declivity shows striking resemblance to the elytra of Alcidine weevils. The rather hard texture, absence of costa, ribs, sulci, tubercles or prominent callosities and the thickness of the fossil conform very closely with the characters of the elytra of the Adelognathi-Brachyderinae of the Curculionidae. In the nature and disposition of the punctures in the narrow striae and in the almost plane and smooth intervals it strongly resembles certain Recent species of the Tanymecids, especially the Indian *Astycus*, but differs essentially from all the living forms in the general shape, thickness, comparative flatness, pronouncedly deflexed declivity and in the much larger size. None of the existing Tanymecids for example if ever exceed 15 mm. (exclusive of the snout) in length, the average size being 12 mm., with the elytra to the total length of the body in the average ratio of 4 : 3. Specialisation in the Brachyderinae has advanced through progressive diminution[5] in the size of the weevils, reduction of the hind wings and loss of powers of flight correlated with the soldering together of the two elytra along the suture. In view of these facts the fossil elytron before me undoubtedly belongs to a more generalised weevil than the existing species and would appear to represent an extinct generalised Tertiary Tanymecid genus, for which the name *Palæotanymecides* is proposed here. The adult weevil was probably at least 20 mm. long exclusive of the snout, large when compared with the generally medium- or even small-sized Tanymecids of the living weevil-fauna of India. The body was rather moderately depressed but elongate, with well developed hind wings; pronotum was most probably narrower than the elytra.

It should be remembered in this connection that the Tanymecids are the best represented of the Adelognathi-Brachyderinae in the Recent weevil fauna of India, where they are relatively richer not only in genera and species than in the other parts of the world but are also abundant as individuals and are very widely distributed. India would indeed appear to be the original home of the Tanymecid stock, which appeared during the Tertiary and ramified into numerous specialised genera, gradually spreading to the other parts of the world.

The Curculionidae, perhaps the largest living family of the Coleoptera, appear as fossils first in the early Tertiary; no less than two-hundred species of weevils have been described from the Palaeogen, 229 species from the Neogen and 50 from the Quaternary. So far only two fossil Tanymecids have been described from the world: *T. seculorum* Scudder[6] from the Oligocene of the Green River, Wyoming, North America and an unnamed species of *Tanymecus*, also by Scudder[7] from the Upper Miocene of Oeningen, Baden, Europe. Fossil Tanymecids have not previously been described from India.

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[5] Murray (*loc. cit.*) believed in an increase in size of the weevils from the Tertiary to the Recent; actually however the Recent weevil fauna abound in minute forms, while the Tertiary weevils were on the whole large-sized everywhere.

[6] Scudder, S. H., 1890, *Tertiary Ins.*, p. 475, pl. viii, fig. 22.

[7] Scudder, S. H., 1895, *Geol. Mag.*, (N.S.) **2**: 119.

Palaeotanymecides hislopi, gen. *et.* sp. nov.

Right elytron 15 mm. long, 6·5 mm. broad; oblong; longitudinal and transverse curvatures slight, the longitudinal curvature less than that of the transverse, somewhat relatively more pronounced in the postero-outer area, rather distinctly flat near the inner margin and gently sloping at the lateral outer margin (Figs. 1 and 2); surface smooth and matt; superficially very much resembling the elytra of the Harpalinae of the Carabidae or of Buprestidae. Base partly damaged but distinctly and broadly sinuate, without an impressed area; inner angle rounded; shoulder not found but judging from the straight outer margin at base and the prominent neighbouring area most probably prominent, indicating that the hind wings were well developed and the prothorax was distinctly narrower than the elytra. Declivity prominently and obliquely deflexed but moderately steep, in the outer margin includes the apical one-third of the length of the elytron but near the suture only one-eighth, so that the anterior border of the declivity is inclined to the suture at about an angle of 45 degrees; the slope of the declivity directed downwards, backwards and slightly outwards. Apex subacute,

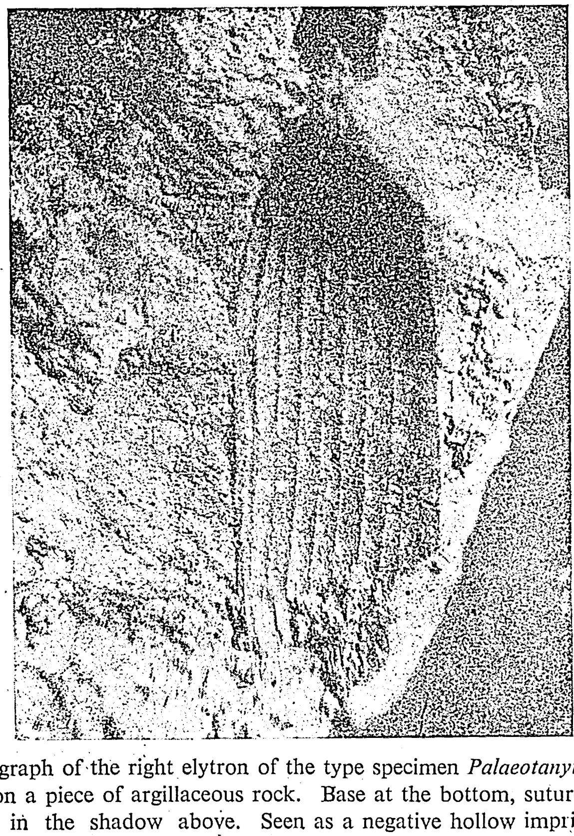


FIG. 1. Photograph of the right elytron of the type specimen *Palaeotanymecides hislopi*, gen. *et* sp. nov. *in situ* on a piece of argillaceous rock. Base at the bottom, suture on the right hand side and declivity in the shadow above. Seen as a negative hollow imprint exactly as in the natural condition. ×4·6 Natural size. (Original photo by the author with wide angle lens).

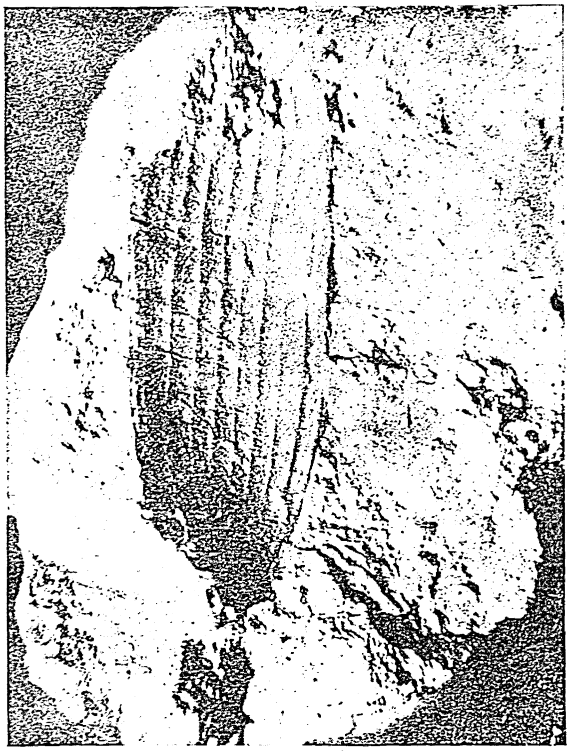


FIG. 2. Photograph of the same specimen in positive 'boss' relief, with lateral inversion secured by differential oblique illumination and short focus lens, to show the true longitudinal and transverse curvatures and the depth of the declivity. Base above, suture on the left hand side. ×4·6 Natural size (Original photo by the author).

distinctly separate. Suture distinct, straight, slightly curved downwards and prominently raised at declivity, its downward curvature less than that of the second or third stria, near the apex somewhat curved outwards also; does not show any evidence of having been soldered together, which is another undoubted indication that the hind wings were well developed. Outer margin straight, almost parallel to the suture except beyond the apical third, *i.e.*, at the declivity where it broadly curves inwards and somewhat downwards to the apex; not emarginately reflexed upwards and outwards as in *Harpalus* (Carabidae); not incised or sinuate for the reception of the hind femur. Impressed lines or longitudinal striae 9, conspicuous, widely separated, narrow, moderately deep but very much shallower and narrower than in *Harpalus*, nearly all parallel and almost all equidistant except at the declivity, where they abruptly converge and coalesce together just before the apex and at the same also becoming somewhat faint; widely, minutely but distinctly and separately punctate characteristically as in *Tanymecus*; the punctures somewhat relatively deeper and rather more conspicuous in the basal half of the elytron than elsewhere. Juxta-sutural (first) stria faint, not quite straight, shallow, indicated only anteriorly and posteriorly but indistinct and evanescent in the middle.

Second stria the deepest and the most prominent, broader than the others, almost sulciform in the posterior half of the elytron, but becoming indistinct at the commencement of the declivity. Third to the eighth striae similar to each other, much narrower and shallower than the second; third and fourth striae coalesce together at the base of the declivity and run backwards, downwards and inwards as a single narrow impressed line to the apex. Outermost (ninth) stria complete, similar to the preceding stria. Intervals distinct, much broader than the striae, almost evenly plane and equally broad, rather becoming gradually narrow in the declivity, smooth, matt, without setigerous or other punctures. Juxta-sutural (first) interval rather narrow. Second interval (between the first and second striae) sharply different from the rest, narrower than the second stria anteriorly but broader posteriorly, almost plane. Third interval differs from the others in being pronouncedly convex. Fourth, fifth, sixth and seventh intervals almost plane and equal to each other in width, except the sixth which is distinctly narrower than the fifth and seventh in the middle only. Eighth and ninth intervals plane but somewhat wider than the seventh. Tenth (outermost) interval narrower than the seventh. In the ninth interval (between the eighth and ninth striae) a faint incomplete impressed line runs irregularly from the base of the elytron to about the basal one-half. There is no trace of the original colour and of the scaly covering. The specimen, therefore, presents a combination of the elytral characters of Buprestidae and Curculionidae.

Type.—On a piece of argillaceous rock described above. Hislop-Hunter collection, found along with fossil seeds and fruits of endogens and angiospermous exogens in 'argillaceous deposits, portions of which have been taken into the body of the volcanic (Trap) rock' near the old Artillary Lines, Takli, near Nagpur, C.P. Property of the British Museum, now temporarily in the collections of the Department of Botany and Geology, Lucknow University. Positive 'boss' relief and negative hollow plaster casts of the type are in the collections of the Zoology Department, St. John's College, Agra.

I thank Prof. Dr. Birbal Sahni, Department of Botany and Geology, Lucknow University, for giving me an opportunity of studying this extremely interesting fossil. My thanks are also due to Prof. Dr . L. P. Mathur, Head of the Biology Department, St. John's College, Agra, for facilities for work and to the Imperial Entomologist, New Delhi, for numerous courtesies.

NOTES ON THE STRUCTURE AND DEVELOPMENT OF THE MALE GENITAL ORGANS IN *CARPOPHILUS* SP. (NITIDULIDAE, COLEOPTERA)

By R. RAKSHPAL, PH.D.
Lecturer in Entomology, The University, Lucknow

CONTENTS

I. INTRODUCTION

I have already studied the structure and development of the reproductive organs in the orders Hemiptera-Homoptera, Lepidoptera and Hymenoptera, and this paper relates to these organs in the order Coleoptera. The reproductive organs have so far been studied by Muir (1919), Singh-Pruthi (1924) and Metcalfe (1932), who have worked out the development of these organs in *Habrocerus capillaricornis*, *Tenebrio moliter* L., *Sitodrepa panica* L., *Gastroidea polygoni* L. and *Anthonomus pomorum* L., while I have selected *Carpophilus* which is a pest of dry fruits and a predator on the honey-bee combs in this part of India.

II. MATERIAL AND TECHNIQUE

The beetle lays its eggs in the honey-bee combs during summer or rainy season if the colony is too weak. In the years 1939–41 while bee-keeping was carried on in the Zoological Laboratory of the Lucknow University, the eggs were collected and reared under suitable conditions in the laboratory and material was obtained for developmental studies.

The larvae were fixed and preserved in 70% alcohol, while the pupae were fixed in Bouin's alcoholic picro-formol. Sections were serially cut at 6–8 μ. For staining, Heidenhain's iron haematoxylin was used in all preparations.

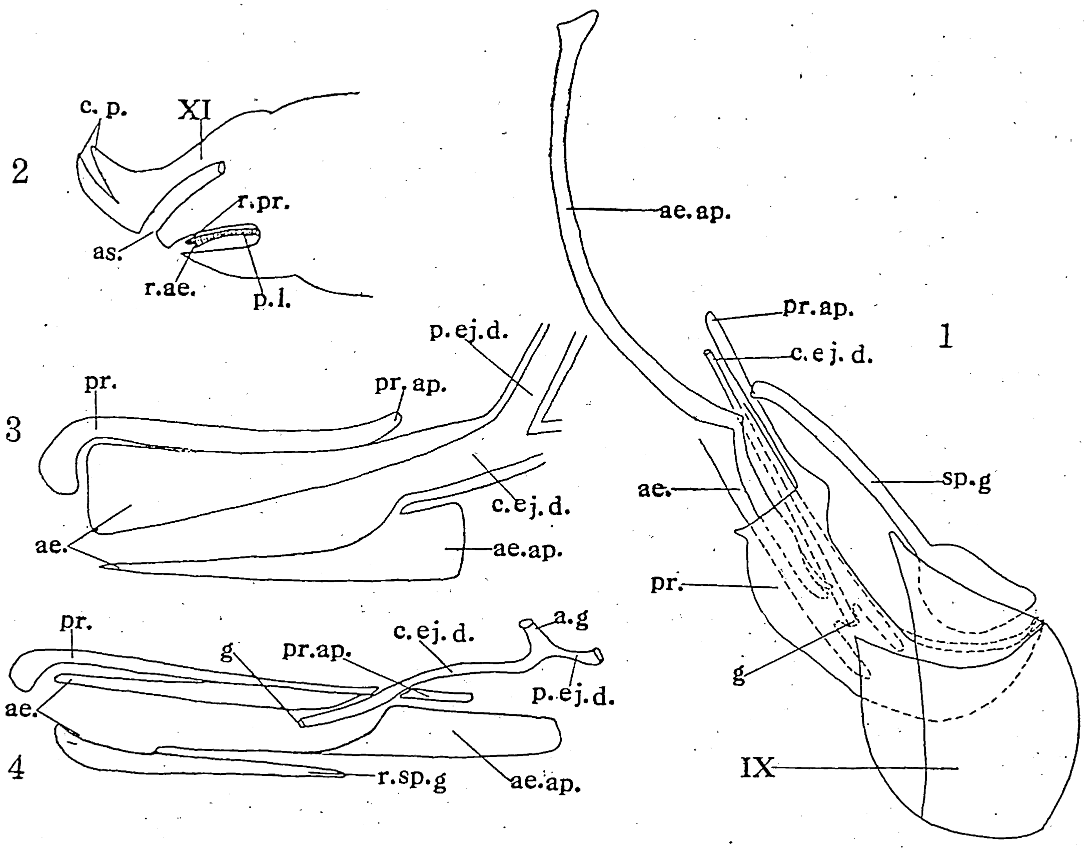
III. STRUCTURE OF THE MALE GENITAL ORGANS OF THE ADULT

Nine abdominal segments are visible in the adult males, of which the ninth (Fig. 1, IX) is very much reduced and is the smallest. Anteriorly it is produced into a pair of processes, while posteriorly its sternum and tergum are fused completely to form a bag-like structure. The genitalia lie within the eighth segment

which is the largest. At the posterior end of this segment there is a concavity which leads to the formation of an eliptical space between the eighth and ninth segments and through which the aedeagus and the parameres project out at the time of copulation. Ventrally this space is guarded by the posterior part of the spiculum gastrale (*vide infra*).

The genitalia.—The genitalia (Fig. 1) consist of three distinct elements: (1) the *aedeagus* (*ae.*) with a very elongated apodeme (*ae.ap.*), (2) a pair of *parameres* (*pr.*) with a single apodeme (*pr.ap.*), and (3) the median *spiculum gastrale* (*sp.g.*).

(1) The aedeagus (*ae.*) is a tube-like structure, from anterior end of which originates a very long solid rod which may be called the *aedeagus-apodeme* (*ae.ap.*) as it provides for muscular attachment. The common ejaculatory duct (*c.ej.d.*)



FIGS. 1–4.—Fig. 1. Genitalia of the adult male. Fig. 2. Diagrammatic, last abdominal segments of the last larval instar. Fig. 3. Digrammatic, vertical longitudinal section of the appendages of the ninth segment of early pupa. Fig. 4. Diagrammatic, vertical longitudinal section of the genitalia of late pupa. *ae*, aedeagus; *ae. ap*, aedeagus-apodeme; *a.g*, accessory gland; *as*, anus; *c.ej.d*, common ejaculatory duct; *c.p*, caudal processes; *g*, gonopore; *p.ej.d*, paired ejaculatory duct; *pr*, parameres; *pr. ap*, parameral apodeme: *r.ae*, rudiments of aedeagus; *r.pr.*, rudiments of parameres; *r.sp.g*, rudiments of spiculum gastrale; *sp.g*, spiculum gastrale; IX segment number.

opens at the posterior end of the aedeagus which remains retracted within itself at the time of repose and thus the gonopore (*g*) also lies within the aedeagus. But at the time of copulation the retracted part of the aedeagus together with the gonopore becomes everted. (2) The parameres (*pr.*) are two flattened pieces which form a scabbard-shaped structure when adpressed together, and between which lies the aedeagus. The proximal ends of these parameres are fused together while the distal portions are discrete. These fused ends form a girdle around the aedeagus and may represent the basal plate of the male genitalia of other Coleoptera. From the ventral side of the fused bases of the parameres originates a rod-like structure which may be called the *parameral-apodeme* (*pr. ap.*) since it serves for muscular attachment. (3) The spiculum gastrale (*sp.g.*) is more or less a T-shaped structure, the head of the T being very much flattened and situated posteriorly; it is this part of the spiculum gastrale which guards the aperture through which the aedeagus and the parameres project out at the time of copulation (*vide supra*). The body of the spiculum gastrale forms its anterior part and lies within the eighth segment; it gives attachment to very strong muscles.

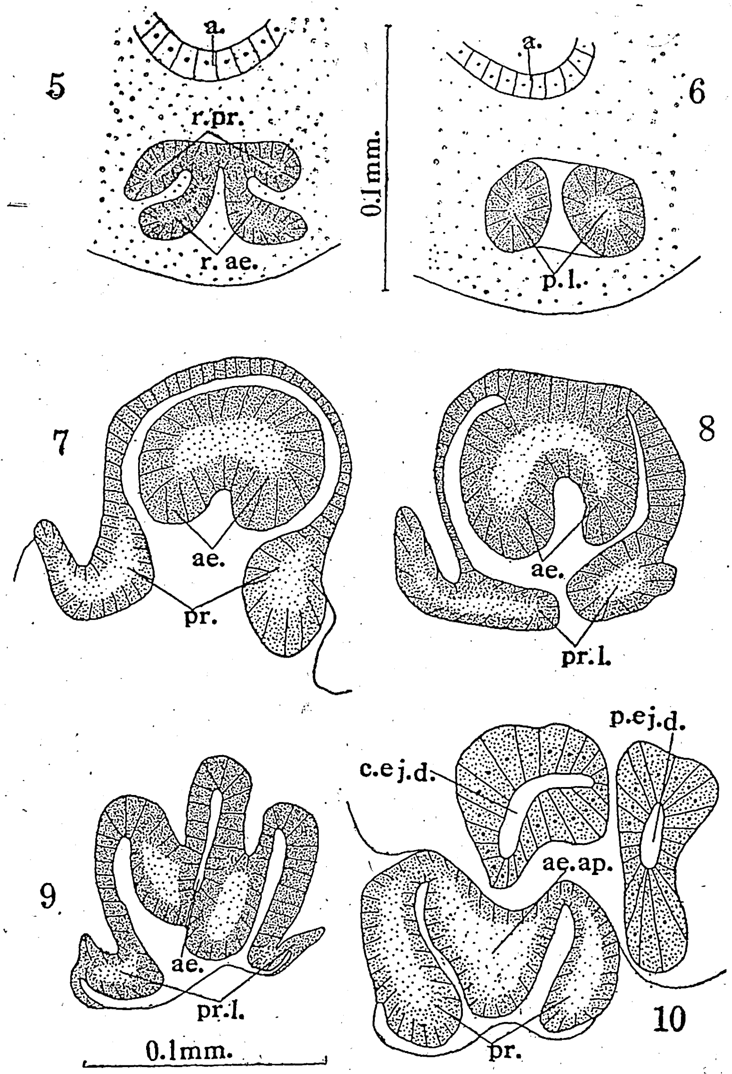
The internal genital organs.—The internal genital organs consist of the *testes*, the *vasa deferentia*, the *ejaculatory ducts* and the *accessory glands*, all of which are paired, and the unpaired *common ejaculatory duct.*

The testes lie dorsally in the fifth and sixth segments. They are more or less cylindrical in shape and consist of a number of distinct follicles. Posteriorly each testis continues into a vas deferens, which is very slender and extends upto the middle of the eighth segment, where it leads into the ejaculatory duct of its own side. The paired ejaculatory ducts are also slender and bend inwards to open into the common ejaculatory duct. At the junction of each vas deferens with its ejaculatory duct opens an accessory gland, which is small but is more or less elongated. The common ejaculatory duct is tubular and enters the aedeagus at its anterior end and continues upto its tip where it opens through the gonopore.

IV. Development of the Male Genital Organs

The genitalia.—In the larva (Fig. 2), there are nine distinct abdominal segments. The first eight segments bear distinct spiracles and can therefore be easily identified. The ninth segment (IX) is very much smaller and bears laterally a pair of processes, the *caudal processes* (*c.p.*). The anus (*as.*) lies on a soft membrane covering the ventral surface of the ninth sternum, and not at the posterior end of this sternum, the soft membrane being perhaps a vestige of the tenth segment. In the early larval stages there are no traces of the genital appendages, but as the larva grows into the last instar, the sternum of the ninth segment invaginates in front of the anus to form a small pouch just above the sternum. At the anterior end of this pouch develops a pair of lobes, the primary-lobes (*p.l.*). As the larva grows, the posterior part of each primary lobe becomes incompletely divided into two by a horizontal longitudinal slit. Thus each lobe is single (Fig. 2) anteriorly, but

double (Fig. 2) posteriorly: the dorsal pair form the rudiments of the parameres (Figs. 2 and 5, *r.pr.*), while the ventral pair are the rudiments of the aedeagus



FIGS. 5–10. Figs. 5 & 6. Transverse sections of the posterior part of the abdomen of last larval instar; from posterior to anterior.—Fig. 5. Posterior part of the genital appendages showing their division. Fig. 6. Anterior part of the genital appendages. Figs. 7–10. Transverse sections of the posterior part of the abdomen of early pupa; from posterior to anterior.—Fig. 7. Posterior part of the genital appendages showing the separation of parameres from aedeagus. Fig. 8. Parameres not yet separated from the aedeagus. Fig. 9. Fusion of the aedeagus-lobes. Fig. 10. Formation of the common ejaculatory duct and the aedeagus-apodeme. *a*, alimentary canal; *ae*, aedeagus; *ae. ap*, aedeagus-apodeme; *c.ej.d.* common ejaculatory duct; *p.ej.d*, paired ejaculatory duct; *p.l*, primary lobes; *pr*, parameres; *pr.l*, parameral lobes; *r.ae*, rudiments of aedeagus; *r.pr*, rudiments of parameres.

(*r.ae.*). The ventral rudiments now begin to fuse with each other leaving a small space between them, and thus forming the tubular *aedeagus*. Anteriorly the rudiments of the parameres are not yet separated from the aedeagus. The spiculum gastrale is not yet developed.

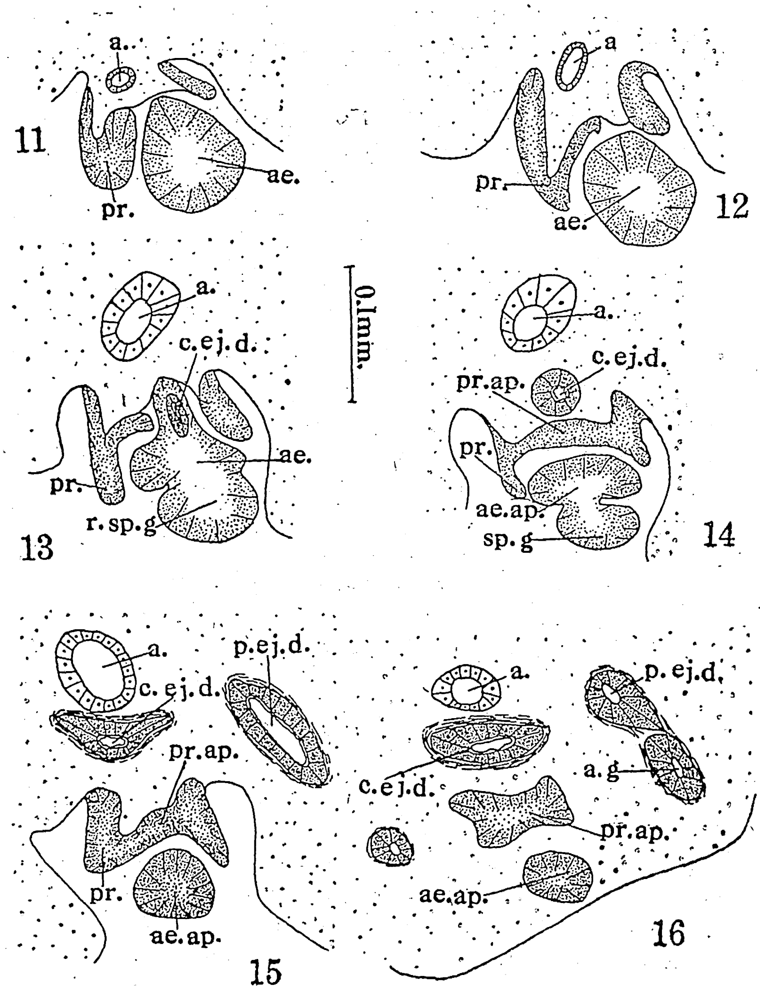
As the larva pupates, further differentiation of the genitalia takes place. The longitudinal slits (Fig. 3) separating the parameres from the aedeagus, now grow further inwards and meet in the middle line posteriorly, but do not meet anteriorly (Figs. 7 and 8); thus while the parameres and the aedeagus become separate posteriorly they remain continuous with each other anteriorly. The parameres grow a little further posteriorly, extending beyond the limits of the aedeagus (Fig. 3), and begin to assume more or less the adult appearance. The anterior part (*ae.ap.*) of the ventral wall of the aedeagus is very thick, and grows beyond its dorsal wall as a solid projection. The solid outgrowth so formed is the rudiment of the aedeagus-apodeme (Fig. 10, *ae.ap.*). The spiculum gastrale is still not developed.

In an advanced pupal stage (Fig. 4) all the parts of the genitalia are distinctly visible. The parameres have further separated from the aedeagus, and have grown so as to assume the adult shape and structure, but they are not yet completely marked off from the aedeagus. The basal parts of the two parameres fuse together and continue to grow anteriorwards to form the rudiment of the parameral apodeme (Figs. 15 and 16, *pr.ap.*). A pair of horizontal longitudinal slits (Figs. 13 and 14, *r.sp.g.*, *sp.g.*), one on each side, appear in each lateral wall of the aedeagus in its anterior part, these two slits deepen inwards and, at a later stage, constrict the aedeagus into two parts, a large dorsal part, and a small ventral part. These slits do not extend to the posterior part of the aedeagus (Fig. 4, *r.sp.g.*) and at this stage, do not even meet in the middle line, so that the ventral division (Fig. 13, *ae.*, *r.sp.g.*) of the aedeagus is not completely separated from the dorsal division. The ventral division is the rudiment of the spiculum gastrale. The aedeagus-apodeme (Fig. 4, *ae.ap.*) which is very rudimentary in the early pupal stage now becomes very much elongated.

Just before the emergence of the nymph, the parameres become completely separated from the aedeagus, but they themselves meet at their bases so as to leave a small space between them through which the aedeagus passes. The parameral apodeme becomes elongated, and so do the aedeagus and the aedeagus-apodeme. The spiculum gastrale becomes completely separated from the aedeagus and comes to lie ventrally to it.

The internal genital organs.—In the early larval stages a pair of testes are present in the sixth abdominal segment, but the efferent ducts are not yet developed. In the last larval instar the vasa deferentia develop and extend upto the seventh segment, but the other parts of the efferent system are still undeveloped. In the early pupal stage the vasa deferentia grow further backwards and extend upto the middle of the ninth segment. The common ejaculatory duct (Figs. 3 and 9, *c.ej.d.*),

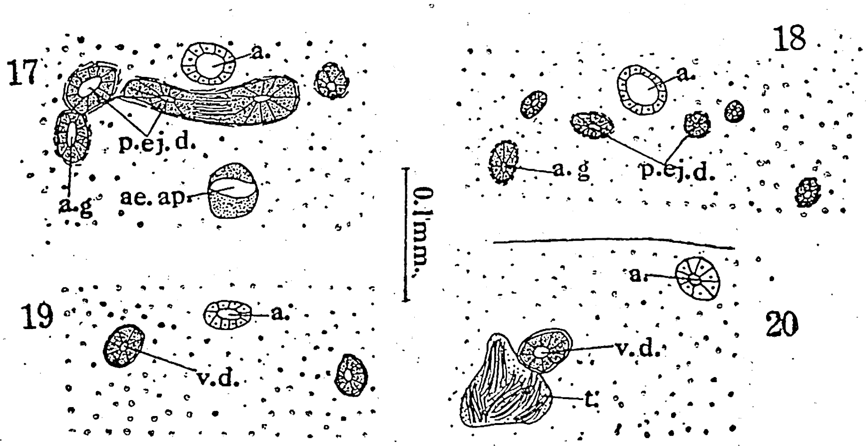
arising as an invagination of the ninth sternum just in front of the base of the aedeagus, is very small, but is divided into two ducts (Figs. 3 and 10, *p.ej.d.*) at its anterior end. The gonopore is situated at the base of the aedeagus. The two ducts so formed from the anterior end of the common ejaculatory duct are the rudiments of the paired ejaculatory ducts. The accessory glands have not yet developed.



FIGS. 11–16. Transverse sections of the posterior part of the abdomen of late pupa; from posterior to anterior.—Fig. 11. Posterior part of the genital appendages. Fig. 12. Same, a few sections more towards the anterior. Fig. 13. Extension of the common ejaculatory duct into the aedeagus. Fig. 14. Origin of the aedeagus and parameral apodemes. Fig. 15. Anterior part of the aedeagus and parameral apodemes. Fig. 16. Origin of the accessory glands. *a*, alimentary canal; *ae*, aedeagus; *ae.ap*, aedeagus-apodeme; *a.g*, accessory gland; *c.ej.d*, common ejaculatory duct; *p.ej.d*, paired ejaculatory duct; *pr*, paramere; *pr.ap*, parameral apodeme; *sp.g*, spiculum gastrale; *r.sp.g*, rudiments of spiculum gastrale.

As the pupa matures, the common ejaculatory duct (Fig. 4, *c.ej.d.*) grows both ways; posteriorly it extends backwards so as to open at the middle of the aedeagus (Figs. 11—13); anteriorly it grows further forwards, and the paired ejaculatory ducts become slightly convoluted. The accessory glands (Figs. 4 and 16, *a.g.*) originate from the anterior ends of the paired ejaculatory ducts. Later the vasa deferentia fuse with the ejaculatory ducts of their respective sides, and thus the efferent system is completed. Just before the emergence of the nymph the common ejaculatory duct extends backwards and reaches the posterior end of the aedeagus and thus the gonopore comes to lie at the apex of the aedeagus.

Histology.—In the larval and early pupal stages the testes consist of a number of distinct follicles filled with small cells with well-marked nuclei, and are enclosed in a thin membranous sheath of connective tissue. But when the nymph is about to emerge, the testicular follicles are found to be filled with elongated spermatozoa (Fig. 20, *t.*). In the early stages the small vasa deferentia form a solid cord of cells surrounded by a thin connective tissue membrane. Later the vasa deferentia (Fig. 19, *v.d.*) develop a lumen, surrounded by a single layer of large cells and a thin connective tissue membrane. The common ejaculatory duct in the early stages consists of a single layer of cells surrounding a wide lumen, but later, a chitinous lining (Fig. 15) is developed and its anterior part becomes surrounded by muscles. The paired ejaculatory ducts (Fig. 17) have the same cell-structure as the common ejaculatory duct, but they are surrounded by a very thin muscular layer and have a very thin chitinous lining. The accessory glands (Fig. 18) are exactly similar in structure to the paired ejaculatory ducts at their time of origin, but they never develop a thin chitinous lining, only their cells becoming enlarged.



FIGS. 17–20. Transverse sections of the abdomen of the late pupa; from posterior to anterior.—Fig. 17. Origin of the paired ejaculatory ducts. Fig. 18. Paired ejaculatory ducts and the accessory glands. Fig. 19. The posterior part of the vas deferens. Fig. 20. Origin of the vas deferens. *a*, alimentary canal; *ae.* aedeagus; *ae.ap*, aedeagus-apodeme; *a.g*, accessory gland; *p.ej.d*, paired ejaculatory duct; *t*, testis; *v.d*, vas deferens.

V. DISCUSSION

It has been shown that a pair of lobes on the ninth sternum divide by horizontal slits to form two pairs, the dorsal pair forming the parameres, and the ventral pair fusing to form the aedeagus in the median ventral line. The spiculum gastrale is developed from the ventral part of the aedeagus. Thus all the elements of the genitalia are developed from a single pair of lobes, *i.e.*, the telopodites of the ninth segment, the coxites not being developed at any stage.

Unfortunately no two workers agree between themselves or with me with regard to this course of development. Verhoeff (1893–1903) suggested that there is a tendency for the coxites to become closely united to the sternites, and eventually losing their separate identity. My observations showing the absence of the coxites supports his suggestion. He further suggested that the parameres are the telopodites of the ninth segment, and that the penis (aedeagus) belongs to the segment posterior to it. This observation of his is not in agreement with that of any other worker. Kerschner (1913) believes that the paired rudiments of the male genitalia are special outgrowths of the body-wall, each rudiment dividing into a lateral and a median part, the median parts of the two sides fusing to form the median intromittent organ, and the lateral parts the valvae. I agree with Kerschner that the male genitalia develop from an original single pair of rudiments but my observations show that these rudiments divide horizontally into dorsal and ventral parts, and not into median and lateral parts. Muir (1918) found that the genital tube (aedeagus) is a single hollow diverticulum from the very beginning and that at no stage it has the appearance of a pair of appendages. His observation is unique and has not been confirmed by any other worker. As regards the lateral appendages, he declared at first that they are merely outgrowths from the aedeagus, but later (1923) suggested that they might be homologues of the coxites. No other worker believes that the coxites are present in the genitalia of the Coleoptera in any form. Singh-Pruthi (1924) is of opinion that coxites are not present in the genitalia of the Coleoptera, and that the median and lateral appendages (aedeagus and parameres) together are homologous with the paramere-lobes (primary-lobes), but later, in the same paper, while comparing the genitalia of Homoptera with those of Coleoptera, he remarks that "the genital papillae of the Coleoptera, on account of their form and position obviously represent the coxites of the ninth sternum, but they do not persist beyond the pupal stage". As a matter of fact, the coxites are not present at any stage of development, and Singh-Pruthi has apparently been led astray by the presence of these structures in Homoptera, with the genitalia of which he compares the genitalia of Coleoptera. Metcalfe (1932) also holds that the aedeagus and the parameres together are developed from a single pair of primary-lobes, and that the coxites are not present at any stage of development.

The basal plate does not form a separate sclerite in this species, only the bases of the parameres fuse with each other leaving a space between them, and forming a girdle-like structure around the aedeagus. This portion of the parameres may

be regarded as the representative of the basal plate. Peytoreau (1895) homologised the basal plate with the ninth sternum, while Bugnion (1910) believed it to be a part of the tenth segment; Hopkins (1911) regarded the basal plate as the apodeme of the ninth tergite, while Singh-Pruthi found that the basal plate is formed from the evaginated part of the genital pouch. On the basis of my studies on *Carpophilus*, I believe that the basal plate, which is never a distinct sclerite, is a modified portion of the bases of the parameres.

As regards the spiculum gastrale, Hopkins (1911) considers that it represents the modified ninth sternite. Singh-Pruthi found that the spiculum gastrale arises as a pair of ectodermal invaginations of the body-wall, just posterior to the ninth sternite. Metcalfe believes that the spiculum gastrale arises from the walls of the genital pocket. According to my study of the development I find that the spiculum gastrale is developed from the ventral part of the aedeagus.

I have shown that all the structures of the genitalia develop from a pair of primary-lobes of the ninth segment, and thus no body-segment takes any part in the formation of the genitalia. This fact is in accordance with the views of Muir, and Metcalfe, but not with those of Singh-Pruthi who derives the spiculum gastrale from the body-wall.

The internal genital organs.—The vasa deferentia are mesodermal in origin and do not extend behind the middle of the eighth segment in the adult. Saling (1907) believes that the mesodermal vasa deferentia are extremely short and that the posterior parts of the so called vasa deferentia are really forward extensions of the ectodermal ejaculatory ducts. Muir thinks that the vasa deferentia which are supposed to be mesodermal in origin, really develop continuously from the ectodermal ejaculatory ducts and are therefore entirely ectodermal in origin. Singh-Pruthi found that the mesodermal vasa deferentia are considerably reduced, if not totally obliterated in the Coleoptera, and that the so-called vasa deferentia are therefore not true vasa deferentia, Metcalfe found that the vasa deferentia were present in all the species examined by her and that they were mesodermal in origin. I entirely agree with Metcalfe.

The common ejaculatory duct is ectodermal in origin and develops as an invagination of the body-wall at the base of the aedeagus. Singh-Pruthi found that "the bottom of the genital pocket is continued after a constriction, as a narrow duct inside the body, and that this is the future ejaculatory duct. Its opening into the pocket lies between the bases of the rudiments of the median lobes (aedeagus)." Thus my observation is in full conformity with that of Singh-Pruthi. Metcalfe also believes that the common ejaculatory duct originates from the invagination of the ectoderm between the rudiments of the genital appendages.

The paired ejaculatory ducts originate from the common ejaculatory duct and the accessory glands from the anterior ends of the paired ejaculatory ducts. Thus both the structures are ectodermal in origin. This statement about the

paired ejaculatory ducts is now generally accepted as correct. However, there is some difference of opinion as regards the origin of the accessory glands.

Escherich (1894) showed that out of two pairs of accessory glands, one pair, the mesodenia, originates from the vasa deferentia, and is thus mesodermal in origin, while the other pair, the ectodenia, originates from the diverticula of the ejaculatory duct and is thus ectodermal in origin. Bordas (1898—99) believes that the glands, one or two pairs, are mesodermal in origin. Singh-Pruthi believes that both pairs of glands are ectodermal as he regards the functional vasa deferentia also as ectodermal. Metcalfe also believes that the glands are ectodermal in origin, although the vasa deferentia, according to her, are mesodermal.

Metcalfe believes that, except the vasa deferentia, all other structures of the efferent ducts are unpaired in origin, because they originate from the unpaired common ejaculatory duct. This seems hardly tenable, as both the paired ejaculatory ducts and the accessory glands originate as paired rudiments. Therefore I believe that except the common ejaculatory duct all other structures are paired in origin in the efferent system.

VI. SUMMARY

The genitalia consist of an aedeagus with a very elongated apodeme, a pair of parameres with a single apodeme, and a spiculum gastrale. All these structures are developed from a single pair of primary lobes on the ninth sternum, which represent the telopodites of the ninth segment.

The internal genital organs consist of paired testes, vasa deferentia, accessory glands, and ejaculatory ducts, and an unpaired common ejaculatory duct. The vasa deferentia are mesodermal as they originate from the testes. The common ejaculatory duct originates as an invagination of the ninth sternum, and is thus ectodermal in origin. The paired ejaculatory ducts originate from the common ejaculatory duct and the accessory glands from the paired ejaculatory ducts, and thus both these structures are ectodermal. The common ejaculatory duct originates as an unpaired rudiment, while all the other efferent ducts are paired in origin.

VII. ACKNOWLEDGMENTS

This work has been carried out in the Zoological laboratories of the Lucknow University under the direct guidance of Prof. K. N. Bahl, to whom I wish to express my deep gratitude for the great help and encouragement and for his painstaking correction of the manuscript. My thanks are also due to the University for the grant of research-fellowship for this work.

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ON VARIATION IN THE NUMBER OF HIND-TIBIAL SPINES IN THE DESERT LOCUST, *SCHISTOCERCA GREGARIA* (FORSKÅL) (ORTHOPTERA, ACRIDIDAE)

By M. L. ROONWAL, M.Sc., PH.D. (CANTAB.), F.N.I.
Major, Indian Land Forces
(*Zoological Survey of India*)

CONTENTS

I. INTRODUCTION

In the course of studies on variation in the desert locust, *Schistocerca gregaria* (Forskål) (Roonwal, 1936–1947*c*), the number of tibial spines on the hind or metathoracic pair of legs was studied in various types of individuals in both the *gregaria* and the *solitaria* phases and with a varying number of eye-stripes (5–8, *vide* Roonwal, 1936, 1937, 1945, 1945*c*, 1947*a*). This was done with a view to determine whether or not any correlation exists between the number of tibial spines and other characters such as eye-stripes, phase, etc.

The spines, exclusive of the two pairs of tibial spurs (Fig. 1, *sr.*) whose number is always constant, on the outer and inner sides of both the right and left tibia were counted. In the *solitaria* phase sixty-one adults were examined, thus (Table 1 *a–g*): 5-eye-striped: 2 ♂♂, 1 ♀; 6-eye-striped: 18♂♂, 10♀♀; 7-eye-striped: 9♂♂, 20♀♀; and 8-eye-striped: 1♀. In the *gregaria* phase (all 6-eye-striped) thirty-two adults (17♂♂, 15♀♀) were examined (Table 2 *a*, *b*). In addition to these, a few phase *gregaria* hoppers of the second to fifth stages were also examined (Table 4).

II. RESULTS

It will be seen from the analysis of the data (Table 3 *a*, *b*) that, while no sharp distinction is possible in regard to the number of hind-tibial spines in the various types of individuals, certain general tendencies are noticeable, as discussed below. The following remarks apply mainly to the 6- and 7-eye-striped individuals; the number of 5- and 8-striped individuals available for examination was too small for satisfactory comparisons.

Firstly, in all types of individuals generally, the number of both the outer and the inner spines varies between 8–12; that of the outer spines is mostly frequently 9 (in some cases closely followed by 10) and that of the inner spines most frequently 11. In the same tibia the outer spines are almost always fewer than the inner, the difference being mostly 2, less often 1, and in a few cases 3 and 0.

Exceptionally, the outer spines are more numerous (by one) than the inner (Table 1 *a*). The number of spines varies irregularly in the right and left tibia of the same individual.

TABLE 1 *a–g*. *Number of hind-tibial spines* (*exclusive of tibial spurs*) *in* Schistocerca gregaria, *phase* solitaria

(Rt., right; Lt., left)

(1 *a*)
5 eye-stripes—2 ♂♂

Rt. tibia		Lt. tibia	
Outer	Inner	Outer	Inner
11	10	11	10
..	..	9	11
11	10	9–11	10–11

(1 *b*)
5 eye-stripes—1 ♀

Rt. tibia		Lt. tibia	
Outer	Inner	Outer	Inner
10	11	10	11

(1 *c*)
6 eye-stripes—18 ♂♂

Rt. tibia		Lt. tibia	
Outer	Inner	Outer	Inner
8	10	9	11
..	..	9	10
..	..	9	11
10	11	10	11
..	..	10	11
..	..	9	11
10	11	..	..
10	11	9	11
10	11	..	..
..	..	10	10
10	10	10	11
..	..	10	11
8	11	10	11
9	11	9	11
9	11	9	11
..	..	9	11
10	11	9	11
9	11	9	12
8–10	10–11	9–10	10–12

(1 *d*)
6 eye-stripes—10 ♀♀

Rt. tibia		Lt. tibia	
Outer	Inner	Outer	Inner
9	11	9	11
9	10	..	..
9	10	..	..
9	10	..	..
..	..	10	11
9	11	..	..
12	12	11	11
11	11	9	11
9	11	9	11
9	11	9	11
9–12	10–12	9–11	11

(1 *e*)
7 eye-stripes—9 ♂♂

Rt. tibia		Lt. tibia	
Outer	Inner	Outer	Inner
9	11	10	11
9	11	8	11
8	8	..	..
9	11	10	10
9	11	9	11
10	11	10	11
9	11	9	11
8	10	9	11
8	11	9	11
8–10	8–11	8–10	10–11

(1*f*)

7 eye-stripes—20 ♀ ♀

Rt. tibia		Lt. tibia	
Outer	Inner	Outer	Inner
9	11	..	..
9	11	9	11
10	11	..	..
..	..	10	10
9	10	10	10
9	10	8	9
..	..	10	11
..	..	10	12
9	11	..	..
..	..	9	11
9	11	9	11
10	11	..	..
..	..	8	11
9	11	9	11
9	11	..	..
..	..	8	11
9	11	9	11
9	11	10	10
9	11	10	11
9	11	10	9
9–10	10–11	8–10	9–12

(1*g*)

8 eye-stripes—1 ♀

Rt. tibia		Lt. tibia	
Outer	Inner	Outer	Inner
10	11	9	11

Secondly, it will be seen that *solitaria* individuals exhibit a greater degree of variability than *gregaria* ones, the number of outer and inner spines varying as follows, the total numerical range covered in each case being given within square brackets:

		ph. *solitaria*	ph. *gregaria*
Outer spines	..	8–12 [5]	8–10 [3]
Inner spines	..	8–12 [5]	10–12 [3]

Thirdly, while the number of outer spines is, as already stated, most frequently 9, an interesting peculiarity is noticeable here. In 6 eye-striped *solitaria* and *gregaria* males the most frequently occurring number of spines is nearly equally divided between 9 and 10, as shown by the following frequencies respectively:—*sol.* ♂♂: 13 and 12; *gr.* ♂♂: 9 and 8. In the remaining types of individuals the predominant frequency is 9.

Finally, the number of inner spines is most frequently 11 in all types of individuals.

The lack of a clear correlation between the number of tibial spines and that of the eye-stripes, etc., may be connected with the fact that, unlike eye-stripes (Roonwal, 1937, 1947 *a*) and antennal segments (Rao, 1938; Mukerji and Batra,

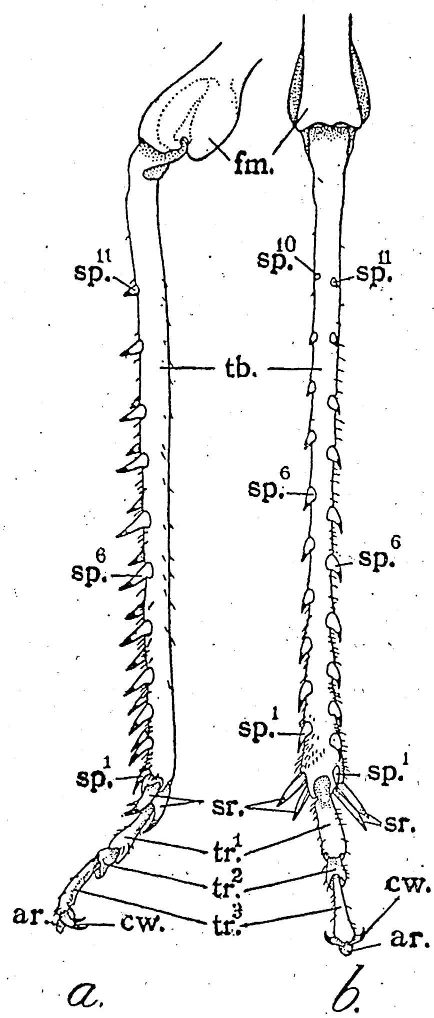

FIG. 1. (*a*), (*b*).—Portion of left hind or metathoracic-leg of *Schistocerca gregaria* (Forskål) to show tibial spines. ♀. No. 1183/H 5 of Zool. Surv. of India Coll.; Collected Nov. 15, 1937, at Nakakharari, Lasbela State, Baluchistan; phase *solitaria*; 6 eye-stripes; 27 antennal segments; E/F 2·03; P 11·9 mm.; H 9·5 mm.; M 6·9 mm. × about 3. (*a*) Side-view from inner side; (*b*) dorsal (front) view. *ar.*, arolium (sometimes also called pulvillus or empodium); *cw.*, claws; *fm.*, portion of hind-femur; *sp.* $^{1-11}$, tibial spines 1–11; *sr.*, tibial spurs; *tb.*, hind-tibia; *tr.* $^{1-3}$, tarsal joints 1–3.

1938; Rao and Gupta, 1939), the number of tibial spines evidently does not increase during post-embryonic development. An examination of some phase *gregaria* hoppers in the second to fifth stages showed (Table 4) that even as early as the second stage the number of the outer spines is 8–11 and that of the inner 11–12; there is no increase with further development.

TABLE 2 *a–b*. *Number of hind-tibial spines (exclusive of tibial spurs) in* Schistocerca gregaria, *phase* gregaria (*from swarms*), 6- *eye-striped*

(Rt., right; Lt., left)

(2 *a*)—17 ♂♂

Rt. tibia		Lt. tibia	
Outer	Inner	Outer	Inner
8	10	8	11
8	11	..	..
8	11	9	11
9	11	10	10
..	..	9	10
9	11	..	..
..	..	10	11
10	11	..	..
9	11	..	..
9	11	10	11
..	..	9	10
10	11	..	..
9	11	..	..
..	..	10	11
10	11	10	11
..	..	8	11
9	11	..	..
8–10	10–11	8–10	10–11

(2 *b*)—15 ♀♀

Rt. tibia		Lt. tibia	
Outer	Inner	Outer	Inner
9	11	10	11
10	11	..	..
9	10	9	10
..	..	9	11
..	..	9	11
10	11	..	..
..	..	9	11
..	..	9	12
..	..	9	10
9	11	..	..
9	11	9	11
10	11	..	..
8	11	10	11
9	11	10	12
9	11	10	11
8–10	10–11	9–10	10–12

TABLE 3 *a–b*. *Frequency distribution and range of the number of hind-tibial spines (exclusive of tibial spurs) in* Schistocerca gregaria. (*From Tables* 1 *and* 2)

(3 *a*)—Outer spines

Phase and sex	No. of eye stripes	Number of individuals in each category																		Range (number of spines) in both fibia	
		Spines in right tibia						Spines in left tibia						Spines in both tibia							
		No. of cases	8	9	10	11	12	No. of cases	8	9	10	11	12	No. of cases	8	9	10	11	12		
sol. ♂♂	5*	(1)	..	..	..	1	..	(2)	..	1	..	1	..	(3)	..	1	..	2	..	9–11	*sol.* 8–12
	6	(11)	2	3	6	..	..	(16)	..	10	6	..	..	(27)	2	13	12	..	..	8–10	
	7	(9)	3	5	1	..	..	(8)	1	4	3	..	..	(17)	4	9	4	..	..	8–10	
sol. ♀♀	5*	(1)	..	..	1	..	..	(1)	..	..	1	..	..	(2)	..	..	2	..	..	10	
	6	(9)	..	..	..	1	1	(6)	..	4	1	1	..	(15)	..	**11**	1	2	1	9–12	
	7	(14)	..	12	2	..	..	(15)	3	5	7	..	..	(29)	**3**	**17**	9	..	..	8–10	
	8	(1)	..	..	1	..	..	(1)	..	1	..	..	..	(2)	..	1	1	..	..	10	
gr. ♂♂	6	(12)	3	6	**3**	..	..	(10)	2	3	5	..	..	(22)	5	**9**	**8**	..	..	8–10	*gr.* 8–10
gr. ♀♀	6	(10)	1	6	3	..	..	(11)	..	7	4	..	..	(21)	1	**13**	7	..	..	8–10	

* Phase uncertain, but not wild *gregaria*.

(3 *b*)—Inner spines

Phase and sex	No. of eye stripes	Number of individuals in each category: Spines in right tibia: No. of cases	8	9	10	11	12	Spines in left tibia: No. of cases	8	9	10	11	12	Spines in both tibia: No. of cases	8	9	10	11	12	Range (number of spines) in both tibia	
sol. ♂♂	5*	(1)	..	..	1	..	..	(2)	..	..	1	1	..	(3)	..	..	2	1	..	10–11	*sol.* 8–12
	6	(11)	..	..	2	9	..	(16)	..	..	2	13	1	(27)	..	..	4	22	1	10–12	
	7	(9)	1	..	1	7	..	(8)	..	..	1	7	..	(17)	1	..	2	14	..	8–11	
sol. ♀♀	5*	(1)	..	..	..	1	..	(1)	..	..	..	1	..	(2)	..	..	..	2	..	11	
	6	(9)	..	..	3	5	1	(6)	..	..	..	6	..	(15)	..	..	3	11	1	10–12	
	7	(14)	..	..	2	12	..	(15)	..	2	3	9	1	(29)	..	2	5	21	1	9–12	
	8	(1)	..	..	..	1	..	(1)	..	..	..	1	..	(2)	..	..	..	2	..	11	
gr. ♂♂	6	(12)	..	..	1	11	..	(10)	..	..	3	7	..	(22)	..	..	4	18	..	10–11	*gr.* 10–12
gr. ♀♀	6	(10)	..	..	1	9	..	(11)	..	..	2	7	2	(21)	..	..	3	16	2	10–12	

* Phase uncertain, but not wild *gregaria*.

TABLE 4. *Number of hind-tibial spines (exclusive of tibial spurs) in* gregaria *phase hoppers of* Schistocerca gregaria

Stage (Number examined are given in brackets)	Outer	Inner	Difference between outer and inner in same tibia
II (5)	8–11	11–12	0–4
III (5)	8–11	10–12	0–3
IV (5)	9–11	10–12	1–2
V (2)	9–10	11	1–2

III. SUMMARY

1. An analysis was made of variation in the number of hind-tibial spines (exclusive of the two pairs of tibial spurs whose number is constant) in various types of individuals of *Schistocerca gregaria*, namely, in *solitaria* and *gregaria* phases and with a varying number of eye-stripes (5–8).

2. The number of outer and inner spines varies between 8–12, that of the former being most frequently 9 (in some cases, *viz.*, in 6- eye-striped *solitaria* and *gregaria* males, closely followed by 10) and that of the latter most frequently 11. In the same tibia the outer spines are generally fewer in number than the inner.

3. Individuals in phase *solitaria* show a greater degree of variability as regards the number of hind-tibial spines than those in phase *gregaria*.

4. The number of spines does not show any clear correlation with that of the eye-stripes.

5. The number of spines does not increase during post-embryonic development, the adult number being already present in the early hopper stages.

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ON THE STRUCTURE AND FORMATION OF SPERMATOPHORE IN THE COCKROACH, *PERIPLANETA AMERICANA* (LINN.)

By P. D. GUPTA

Lecturer in Zoology, University of Lucknow

CONTENTS

I. INTRODUCTION

Although only a few workers have so far observed the process of copulation in cockroaches, it is established that a spermatophore, formed within the ejaculatory duct of the male, is transferred to the female during the act of copulation in all the members of the family Blattidae, as in the other families of Orthoptera. In fact, the essential factor in the act of copulation is the deposition of the spermatophore. The structure and formation of the spermatophore has been described by Zabinski (1933) and Qadri (1938) in *Blatta orientalis* Linn., but, as their accounts differ from each other, it became necessary to verify their statements. The present observations were undertaken on the cockroach, *Periplaneta americana*, commonly available in the United Provinces.

II. THE STRUCTURE OF THE SPERMATOPHORE

On dissecting a female cockroach, which has just mated, a fully formed spermatophore can be readily seen attached to the spermathecal papilla, within the gynatrium. It is a pear-shaped structure, about 1·3 mm. in diameter, with its narrow end directed posteriorly; its outer covering shows several projections and depressions formed as a result of its being compressed between the sclerites of the female genitalia. The attached surface of the spermatophore bears, towards its broader end, an opening through which the spermatic fluid passes from the spermatophore into the spermatheca of the female.

The wall of the spermatophore is about 400 μ in thickness, and is made up of three non-cellular layers. Each one of these layers stains differently in sections treated with haematoxylin and eosin and can therefore be readily distinguished one from the other. The outer layer is thin and looks like chitin; it is about 60 μ in thickness; it becomes perfectly transparent in cedar oil and takes up a light pink stain. The middle layer is the thickest, being about 180 μ in thickness; its

structure appears like a mesh-work of fibres, which become translucent in cedar oil and take up a violet stain. The inner layer is about 150 μ in thickness; it remains

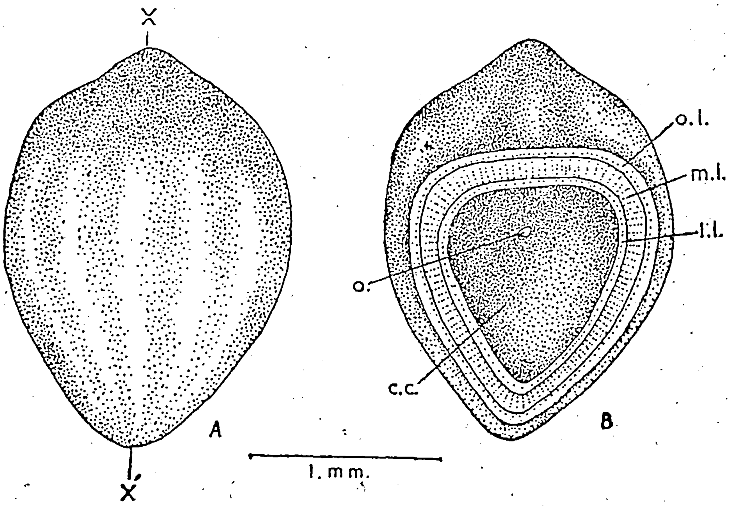

FIG. 1. A. A spermatophore as deposited in the genital chamber of the female cockroach, *Periplaneta americana* Linn. (Ventral view).

B. The same with a portion of the wall removed to show its three layers and the central chamber (semi-diagrammatic). *c.c.*, central chamber; *i.l.*, inner layer; *m.l.*, middle layer; *o.*, opening of the spermatophore; *o.l.*, outer layer; *x.x.*, denotes the axis along which the section in T.-Fig. 2 has been taken.

dull in cedar oil but as it takes up a scarlet red stain, it appears as most prominent of the three layers in stained sections. The central chamber measuring 550 μ

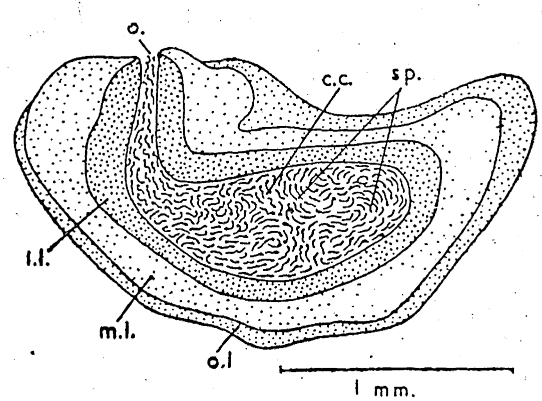

FIG. 2. The spermatophore in sagittal section. *c.c.*, Central chamber; *i.l.*, inner layer; *m.l.*, middle layer; *o.*, opening of the spermatophore; *sp.*, spermatozoa.

has masses of spermatozoa floating in a thin clear fluid; the spermatozoa take up a deep blue stain, while the fluid which appears finely granular takes up a purple stain.

My observations on the structure of the spermatophore are in agreement with those of Zabinski (1933) who says, "The spermatophore, about the size of a pin-head, is at first pear-shaped, but later on becomes deformed by pressure; when fresh it is white and has the consistency of hard butter. It consists of an outer and an inner wall with an intervening layer of a vacuolated material." Zabinski's figure clearly shows that the spermatophore has a single chamber in which the spermatozoa are stored. Qadri (1938), on the other hand, states, "A fresh spermatophore consists of a number of capsules full of spermatozoa bounded by the outer layers. If a spermatophore is stained with Delafield's haematoxylin and counter-stained with eosin, it can be observed that the outer layers are pinkish while the sperm-capsules stain blue". I find that the spermatophore is really a single capsule as described by Zabinski (1933) and is not made up of a number of capsules as described by Qadri (1938), nor does the sperm-capsule take up a blue stain as stated by Qadri. It is only the spermatozoa contained within the sperm-capsule that take up a blue stain. As regards the contents of the spermatophore both Zabinski and Qadri failed to observe that the spermatozoa float in a fluid which takes up a purple stain distinct from the blue stain of the spermatozoa.

III. Formation of the Spermatophore

My observations are based on a study of whole mounts as well as on the series of sections of the ejaculatory duct and its contents from the beginning to the end of the process in successive formations of the spermatophores.

The rudiments of the spermatophore first appear at the anterior end of the ejaculatory duct, only 20 to 24 hours after the final moult; these rudiments are paired, each being formed separately in the two limbs of the ejaculatory duct; after about 12 hours the two rudiments begin to unite into one, but the paired origin can be marked even on the fourth or the fifth day when the developing spermatophore still shows a bicornuate appearance at its anterior end. The rudiments consist of a thick gelatinous substance, the consistency and staining properties of which indicate beyond doubt that it is a secretion from the large peripheral accessory glands (utriculi majores). As more and more of this secretion is deposited in layers, it gradually forms the inner layer of the wall of the spermatophore which keeps growing posteriorly. With the establishment of the first layer of the wall, the central chamber of the spermatophore receives the sperms from the seminal vesicles and its fluid contents from the median accessory glands.

Another layer (the middle one) begins to be laid for the first time on the fourth day at the posterior end of the developing spermatophore just outside the inner layer. The spermatophore increases in size and slowly descends down the ejaculatory duct till the end of the fifth or sixth day, when it occupies almost half the length of the duct; the middle layer gradually extends all the way round and completely surrounds the inner layer, except at the opening of the spermatophore. That the middle layer is secreted by the epithelial lining of the ejaculatory duct is

proved by the fact that both in consistency and staining properties the epithelial secretion and the substance of the middle layer are closely similar.

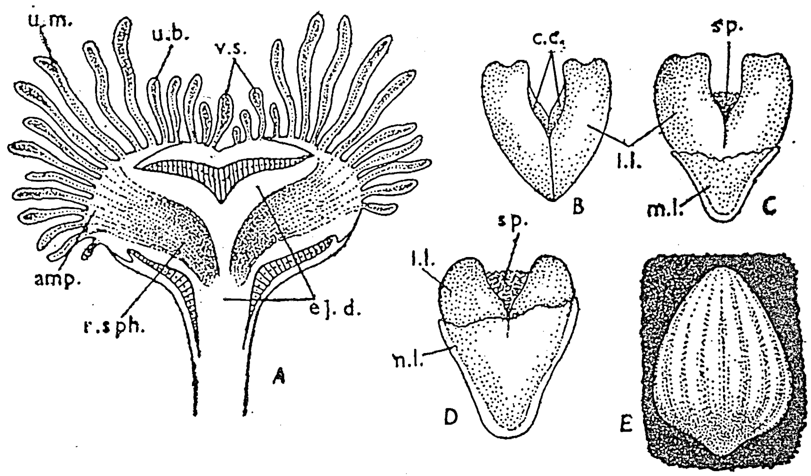

FIG. 3. Successive stages in the formation of a spermatophore (Diagrammatic).

A. The ampullae and the anterior portion of the ejaculatory duct in horizontal section showing secretion from the gland forming rudiments (inner layer of wall) of the spermatophore.

B. The two rudiments (inner layer of the wall) united posteriorly.

C. Beginning of the formation of the middle layer of the wall.

D. The formation of the middle layer in further progress.

E. A fully formed spermatophore. *amp.*, ampulla; *c.c.*, central chamber; *ej.d.*, ejaculatory duct; *i.l.*, inner layer; *m.l.*, middle layer; *r.sph.*, rudiment of spermatophore; *sp.*, spermatozoa; *u.b.*, utriculus brevioris; *u.m.*, utriculus majoris; *v.s.*, vesiculae seminales.

So long as the spermatophore remains within the ejaculatory duct its wall consists only of two layers, the inner and the middle, there being no trace of the outer layer, which is laid only while the spermatophore is being attached to the spermathecal papilla of the female cockroach. As to the origin of the secretion for the outer layer, there are two possibilities: either it comes from the colleterial glands of the female, or it is secreted by the phallic gland (conglobate gland) of the male. The first possibility is excluded on the following three considerations: (i) that the colleterial glands open at the base of the inner valvulae in the posterior portion of the gynatrium, behind the place where the spermatophore is deposited, (ii) that as definitely known the secretion of the colleterial glands contributes to the formation of wall of the egg coccoon, and (iii) that with haematoxylin and eosin the fresh secretion of the colleterial glands takes up a deep red stain, while the outer layer of the wall of the spermatophore is coloured only light pink. The second possibility, *i.e.*, the secretion coming from the phallic gland finds support from the following facts: (i) that the opening of the phallic gland comes to lie very close to the place of the deposition of the spermatophore into the anterior part of the gynatrium, (ii) that the phallic gland is actually most active on or about the sixth day after the final moult, when the spermatophore has already been

formed within the ejaculatory duct and is ready to be transferred to the female; it is only at such a time that the tubules of the phallic gland present an extremely turgid appearance and are full of secretory material, (iii) that the colour, consistency and staining properties of the secretion of the phallic gland are closely similar to those of the outer layer of the wall of the spermatophore. The natural conclusion, therefore, is that the outer layer is formed from the secretion of the phallic gland of the male cockroach.

The mass of the spermatozoa within the spermatophore comes from the seminal vesicles, but the fluid in which the spermatozoa float is, I believe, the secretion of the small median accessory glands (utriculi breviores) in the male genital organs. The fluid resembles the secretion of these glands in its consistency and staining properties, and secondly, these glands are situated very close to the seminal vesicles. As regards the function of this fluid, Ito (1924) writes that the male accessory glands of *Blatta orientalis* form a spermatic fluid which stimulates the activity of the spermatozoa. As far as I think the fluid forms a suitable medium for keeping the sperms together into the spermatophore from the time they leave the seminal vesicles upto the time they reach the spermatheca of the female; it is probable that the fluid nourishes the sperms during the whole of this period and even afterwards within the spermatheca.

Zabinski (*op. cit.*) believes that the inner layer of the wall of the spermatophore is formed by the secretion of the smaller tubules (median accessory glands) and that the outer parts by that of the longer tubules (large peripheral accessory glands). Qadri (*op. cit.*), on the other hand writes, "The form and mode of spermatophore formation appears to be quite different from what Zabinski has described. The writer has observed the process from the first day of emergence till the transmission of the spermatophore to the female. The outer layers appear to be formed of the white gelatinous substance of the larger and peripheral accessory glands; the sperm-capsules appear to be of a different nature and are probably secreted by the smaller and median accessory glands." The above statements of both, Zabinski and Qadri are in themselves inadequate and do not separately account for the formation of the three layers of the spermatophore. I have already described the fate of the secretion of the small median accessory glands and come to the conclusion that it forms the fluid in which the spermatozoa float within the spermatophore. There are additional reasons to show that neither the sperm-capsules (as suggested by Qadri) nor the inner layer of the wall (as mentioned by Zabinski) can be formed from the secretion of the small median accessory glands: (i) The spermatophore does not contain a number of sperm-capsules described by Qadri. (ii) The median accessory glands, being fewer in number and smaller in size, are hardly capable of secreting sufficient material for the formation of the thick inner layer. (iii) These glands occupy a median position beyond the place of initial formation of the inner layer, and that their secretion possesses consistency and staining properties different from those of the inner layer.

I agree with Qadri that the large peripheral accessory glands produce a white thick gelatinous substance but I have already shown that the substance forms the inner layer and not the outer layers as described by Zabinski and by Qadri. The formation of the middle layer has not at all been discussed by either of them but it appears that they regard this layer along with the outer one as being formed from the secretion of the large peripheral accessory glands. The consistency and staining properties of these layers are totally different from those of the secretions of both the types of accessory glands, and this fact rules out altogether the possibility of the formation of the middle and the outer layers from the secretion of these glands. Their assertion regarding the outer layer is further negatived by the fact that the spermatophore possesses a wall made up only of inner and the middle layers as long as it is inside the ejaculatory duct, the outer layer is added only after the spermatophore has actually passed out of the duct.

IV. Conclusions

The spermatophore is a single, pear-shaped capsule, its wall consisting of three layers: an inner, a middle, and an outer. The inner layer of the wall is secreted by the large peripheral accessory glands (utriculi majores), the middle layer by the epithelium of the ejaculatory duct, and the outer layer is formed from the secretion of the phallic gland outside the ejaculatory duct while it is being attached to the spermathecal papilla of the female.

The contents of the spermatophore are a mass of spermatozoa which float in a thin clear fluid; the spermatozoa are received from the seminal vesicles of the male cockroach, while the fluid comes from the median accessory glands (utriculi breviores).

V. Acknowledgment

The work was mainly carried on in the Zoology Department of the Lucknow University under the supervision of Professor K. N. Bahl to whom I wish to record my respectful thanks for his interest and painstaking correction of the manuscript. I am also indebted to Dr. M. L. Bhatia of the University of Lucknow for his valuable help in preparation of this paper. To the Lucknow University I am thankful for the award of a Research Fellowship.

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THE IDENTIFICATION OF *BRACON** *HEBETOR* (SAY) AND *B. BREVICORNIS* (WESMAEL)

By K. B. Lal
Entomologist to Government, U.P., Cawnpore

I. Introduction

The present contribution is an attempt to clarify the identity of two species of Braconidae, *Bracon hebetor* (Say) and *B. brevicornis* (Wesmael) and reports of their occurrences in Northern India. As will appear from the following para some confusion has existed in regard to both, the identity and the reports, perhaps one leading to the other.

Glover and Chatterji (1936) reported *B. hebetor* parasitising *Eublemma amabilis* Moore, *Holcocera pulverea* Meyr. and *Eublemma scitula* Ramb., all predators of the lac insect and considered it potentially very important in the control of the first two. The authors also believed *hebetor* to be rare in Northern India and imported a consignment of this species from Ceylon for studying its possibilities in biological control. Ghulamullah (1939), however, reported *hebetor* to be common in Delhi area, attacking such well-known pests as *Antigastra catalaunalis* Dup., *Laphygma* sp. and *Gnorimoschema operculella* Zell. (?) and further that it could be induced to parasitise *Platyedra gossypiella* Saund., *Earias fabia* Stoll. and *E. insulana* Boisd. On the other hand, a number of specimens from the above-mentioned hosts and reared in the laboratory of the Imperial Entomologist at New Delhi, were identified by me as *B. brevicornis*. More recently, *B. hebetor* has been reported from South India by Krishnamurti and Rao (1944) to be a natural parasite of *Adisura atkinsoni* Moore but capable of being reared in the laboratory on *Corcyra cephalonica* Staint. and *B. brevicornis* by Krishnamurti and Appanna (1944) to be a natural parasite of *C. cephalonica* but capable of being successfully reared on *A. atkinsoni*. In view of the very close similarity between *B. hebetor* and *B. brevicornis*, doubt has arisen as to whether the species, occurring in India at least, is the one or the other or both are present. Further, since some authors have considered these species identical and some others have, in all probability, referred to one when the other was involved it is desirable to examine the sequence of evidence for the separation of the two species and state the conclusions in the light of an examination of fresh specimens.

This work was carried out in 1939 when I was on the staff of the Imperial Agricultural Research Institute, New Delhi, and has been delayed in publication for want of time to write it up finally. I am grateful to Dr. H. S. Pruthi, formerly Imperial Entomologist, now Plant Protection Adviser to the Government

* This generic name has been adopted in preference to *Microbracon*, which has been in use so far, for the reasons stated by Hincks (1941).

of India, for much helpful criticism and to the Entomologist, Indian Lac Research Institute, Namkum–Ranchi, for the gift of a large number of specimens labelled as *Microbracon hebetor* Say and reared at that Institute.

II. Material

Specimens bred at the Indian Lac Research Institute, Namkum–Ranchi, and at the Imperial Agricultural Research Institute, New Delhi, were examined, including a number bred at different temperatures. These latter were helpful in assessing the true value of the colour markings on the various parts of the body in specific separation.

III. Historical Account

Say (1836) described *hebetor* as a new species of *Bracon*, the genus under which Wesmael (1838) described *brevicornis*. Johnson (1895) separated certain of the species of *Bracon* to go under a new genus *Habrobracon* and included *hebetor* in it. Cushman (1914) considered that *hebetor* of authors other than Say was identical with *brevicornis* but that *hebetor* Say must remain an 'unknown species'. For all practical purposes, therefore, he synonymised these two species and called them *brevicornis*. Muesbeck (1925) in his monograph on *Microbracon* gave *Habrobracon* as one of the synonyms of this genus; therefore, the species of the former came under the latter, but he regarded *hebetor* as distinct from *brevicornis*. In his key for the separation of the species of *Microbracon*, *hebetor* and *brevicornis* are distinguished as follows:—

Antennae of the female 13 to 15 segmented, of male 18 to 23 segmented, first flagellar segment of male antennae usually distinctly longer than the second, the segments beyond the first but very little longer than broad, abdomen smooth and shining, rarely distinctly punctate.—*hebetor*.

Antennae of female 17 to 19 segmented, very rarely 16 segmented, of male 20 to 27 segmented, the first flagellar segment of male antennae usually not distinctly longer than the second, the segments beyond the first one and a half times as long as broad, third, fourth and fifth abdominal tergites nearly always distinctly punctate.—*brevicornis*.

It is interesting to note that Marshall (1885) in his redescription of *brevicornis* mentioned 14-segmented antennae in two female specimens and 21-, 21- and 23-segmented antennae in three male specimens, respectively. Cushman (1914) also characterised *brevicornis* as having 13 to 15 segmented antennae in the female and 20 to 22 segmented in the male. Both the authors, however, recognised that the corresponding figures, originally given by Wesmael, were 17 segments in the antenna of the female and 20 to 26 segments in that of the male. It seems, therefore, that not only in regard to the number of antennal segments but also in other features, specially those of colour, there is considerable confusion about the characters attributable to the two species, *hebetor* and *brevicornis*. In the present study, the key given by Muesbeck (1925) was taken as basis.

IV. Observations and Conclusions

The specimens, reared and identified at Namkum–Ranchi, as *hebetor*, have all 13 to 15 segmented antennae in the female and 18 to 23 in the male. The flagellar segments, both in the female and the male, are very little longer than broad. In most of the specimens the abdominal tergites are smooth and shining rather than punctate. These specimens are typically *hebetor*.

In one set of specimens, reared at New Delhi, many were found to be typically *brevicornis* as judged by characters given in Muesbeck's key. Several of the specimens, however, showed a wider range of variations in their antennal segments than should have been expected for *brevicornis*. For instance, one female specimen had 16 segmented antennae, a rare but not altogether extraordinary condition; another 19 and yet another 20 segmented antennae, while two other specimens showed 21 segmented antennae. Most of the male specimens, however, were typically *brevicornis*. In the female specimens again, the flagellar segments were, in practically all cases, slightly longer than broad and the first flageller segment not very long. All these specimens were reared from one pair of parents attacking *Antigastra catalaunalis* feeding on *Sesamum indicum*. It is, therefore, obvious that they cannot belong to more than one species. If such be the case, they are more closely *brevicornis* than *hebetor*. In this connection it is a noteworthy fact that in none of the specimens of this lot were the antennae less than 16 segmented in the female and 20 segmented in the male.

So far the position was simple and it could have been assumed that there were two species in Northern India, namely, *B. herbetor* and *B. brevicornis*. But doubt arose by the identification of four specimens, from the same lot as above, made by Mr. Nixon of the British Museum. Mr. Nixon determined two of the specimens as *Bracon stabilis* Wesm. and two as *Bracon* (*Habrobracon*) *hebetor* Say. Taking *B. stabilis* first, this species is of course very closely allied to *B. brevicornis* and is distinguished from it by the 'dull and regulose-punctate' abdomen except towards the apex which is 'shining and almost smooth' in *brevicornis*. One is tempted to feel that, if this is all the difference between the two species, it does not amount to very much as there are considerable variations of this kind in *brevicornis* and allied species. Therefore, what Mr. Nixon considered *stabilis* may well be *brevicornis*. The other two specimens are, however, certainly *hebetor*, judging by the characteristics accepted for this species. The female has the antennae 14 segmented and the male 20 segmented and very near the shape commoner in *hebetor* than in *brevicornis*.

A third lot of specimens, reared from different hosts at New Delhi, was also examined. One of them, a female bred from *Earias* sp., had 16 segmented antennae but the shape was typically that of *hebetor* and the abdominal tergites were also smooth. There were a few other female specimens, also bred from *Earias* sp. and with antennae 15 segmented, which could not but be determined as *hebetor*. A few of the male specimens again had the antennal segments

corresponding in number to that of *hebetor* but punctation on the abdominal tergites brought them close to *brevicornis* also. One female specimen, reared from *Heliothis armigera* Hubn., had 21 segmented antennae and on this and other characters was determined as *brevicornis.*

The above facts show that there are considerable variations in the species, *hebetor* and *brevicornis,* not only in respect of colour and other markings on the body, which are taken for granted, but also in such structural characters as the number of antennal segments and the relative proportions of the lengths of the flagellar joints. Muesebeck's key helps to a certain extent in their separation but is apt to break down when intermediate specimens appear. The evidence of biology also cannot alawys be relied upon as the two species have been reared from some hosts, e.g., *Antigastra catalaunalis* Dup., *Adisura atkinsoni* Moore, *Corcyra cephalonica* Staint., which are common to both, though some of the host records may also be due to faulty identification of the parasites.

Much as I believe that utlimately *hebetor* and *brevicornis* may turn out to be identical, with perhaps tolerably well-defined biological or, what is more likely, geographical races, it seems wise at present to consider them as specifically distinct, as identifiable by Muesebeck's key, which should, however, need slight modification. The table of characters for *hebetor* should stand but for *brevicornis* the antennal segments in the female may range from 16 to 21. It appears that in Northern India, both *hebetor* and *brevicornis* occur with perhaps a preponderance of the latter species in Delhi area and of the former in Bihar and areas further east. It is also likely that this incidence of population is in part at least determined by the presence of favourite hosts which the parasites seek.

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(* Not seen in original. Citations from Muesebeck's paper.)

NOTES ON THE BIOLOGY OF SOME MANTIDAE

By R. N. MATHUR, M.SC., PH.D.
Assistant Forest Entomologist, Forest Research Institute, Dehra Dun

INTRODUCTION

These notes are based chiefly on field investigations, carried out under the direction of the Forest Entomologist, on the defoliation of *Dalbergia sissoo* in the irrigated plantations of the Punjab in the summers of 1937 to 1940 and of *Tectona grandis* in Coorg in 1941–42. The biology of four species, viz., *Euantissa ornata* Werner, *Hestiasula brunneriana* Sauss., *H. intermedia* Werner, and *H. pictipes* Wood Mason, recorded at Dehra Dun is also included in the present paper.

The distribution of the mantid fauna is very irregular. In the plantations of the Punjab, 12 species of *Mantidae* have been recorded of which 6 species, viz., *Creoboter urbana* Fabr., *Deiphobe incisa* Werner, *Hierodula* sp. 1, *Parhierodula coarctata* Sauss., *Schizocephala* sp., and *Tenodera superstitiosa* Fabr., have been observed actually feeding on the *shisham* defoliator, *Plecoptera reflexa* Guen., in the wild state (Mathur, 1942). By far the most common species in the plantations are *C. urbana* Fabr., *D. incisa* Werner, *P. coarctata* Sauss., and *Schizocephala* sp. Oothecae, nymphs and adults were utilised in 1938 and 1939 to colonise *D. incisa* Werner and *P. coarctata* Sauss. in some of the irrigated plantations where their presence was doubtful.

From the teak (*Tectona grandis*) plantations of Coorg, 11 species have been recorded, of which four species *Euantissa ornata* Werner, *Gonypeta punctata* Haan, *Leptomantis indica* G. T. and *Tropidomantis guttatipennis* Stål are predators on the teak defoliator, *Hapalia machaeralis* Wlk. *E. ornata* Werner and *T. guttatipennis* Stål are most common of all the species.

No estimate was made of the actual value of the mantids in checking caterpillar population but adults of different species were seen to eat 1 to 3 larvae a day in captivity. These mantids are important enemies of the larvae rather than of the moths and they attack the former with great avidity.

In the field insectaries young nymphs were fed with small diptera, mostly *Siphunculina funicola* de Meij. (which they seemed to prefer), aphids and young caterpillars. Older nymphs and adults were given various larvae and moths, chiefly of *Pyralidae*. Both, caterpillars and the fleshy parts of moths are consumed.

It is probable that *Deiphobe incisa* Werner, *Hierodula* sp. 1, *Schizocephala* sp., have one generation and *Euantissa ornata* Werner, *Hestiasula brunneriana* Sauss., *Hestiasula intermedia* Werner, *Mantis* sp., and *Parhierodula coarctata* Sauss., two generations in a year.

1. AMBIVIA POPA STÅL.

(*ACROMANTINAE*)

Distribution.—Nagerhole (Coorg); Dehra Dun, Kalsi (U.P.).

Life-history and habits.—The adults have been recorded in June 1919 and 1944 at Dehra Dun; in August 1921 from Kalsi, and February 1942 at Nagerhole. One nymph captured on 4th April 1943 at Dehra Dun, transformed into adult (male) on 28th April and lived for another 24 days.

An adult female caught on 10th June 1944, at Dehra Dun, deposited an infertile egg-mass in a cage on 5th July and died after 2 days.

2. AMORPHOSCELIS INDICA GIGLIO-TOS.

(*PERLAMANTINAE*)

Distribution.—Dehra Dun, Kalsi (U.P.).

Life-history and habits.—Adults have been recorded in April from Kalsi, and in August, September, October and November from Dehra Dun. They are generally found resting on the bark of trees. In captivity, two females lived for 15 and 18 days respectively and one male for 11 days. Small flies, caterpillars of some common species and aphids were offered as food to the caged mantids during October-November, but they refused to feed on these insects.

3. CIMANTIS FULIGINOSA WERNER.

(*AMELINAE*)

Distribution.—Nagerhole, Tittimatti (Coorg); Anamalai Hills (Madras); Angul (Orissa).

Life-history and habits.—Recorded in November 1941 and February 1942 from Coorg. This small mantid is smoky brown, very active and flies away when approached.

4. CREOBOTER URBANA FABR.

(*HYMENOPODINAE*)

Distribution.—Arafwala, Changa Manga, Chichawatni, Daphar, Dipalpur, Khanewal, Makhdumpur rakh, Shahdara and Terah plantations (Punjab).

Pusa (Bihar); Katha (Burma); Dehra Dun (U.P.); Sudan.

Life-history and habits.—This mantid is very common on *shisham* (*Dalbergia sissoo*) in the Punjab plantations, feeding on the larvae and moths of *Plecoptera reflexa* Guen., and *Dichomeris eridantis* Meyr. One female caught on 26th July 1938 at Changa Manga laid an egg-mass on 4th August in the insectary at Chichawatni, from which the nymphs hatched on 21st August after an incubation period of 17 days. The nymphs captured in May 1939 transformed into adults towards the end of June. Mathur (1934) has given observations on its life-history in N. India.

Parasites.—Some egg-masses collected in the field were found completely parasitised by Chalcidoid parasites while from others, both, the mantids and the parasites emerged. An egg-mass collected on 5th July 1939, from Khanewal plantation, yielded 66 Chalcidoid parasites.

5. DEIPHOBE INCISA WERNER.

(*MANTINAE*)

Distribution.—Chichawatni, Daphar, Dipalpur, Khanewal, Miranpur and Terah plantations (Punjab).

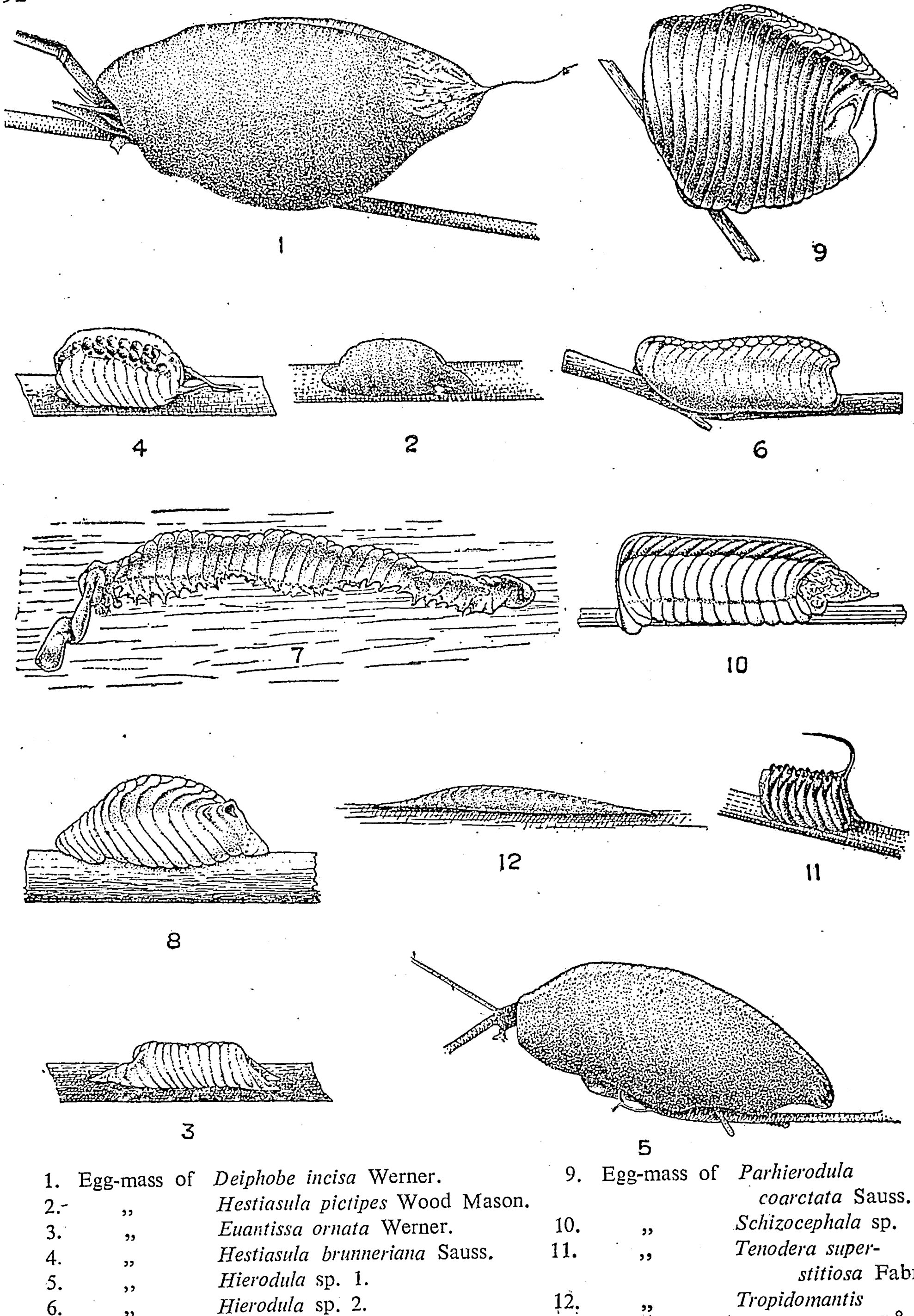
Sagoda (C.P.); Etawah, Haldwani (U.P.); India.

Life-history and habits.—This mantid has been found in abundance at Chichawatni plantation on *Acacia arabica*, bushes, *Dalbergia sissoo*, and *Zizyphus jujuba*, during July, both in the adult and ootheca stages. The nymphs and adults have been observed to feed on the larvae and moths of *P. reflexa* Guen., *D. eridantis* Meyr., and *Tephrina disputaria* Guen., in the wild state. Its egg-masses (Fig. 1) and nymphs resemble *Deiphobe* sp., which has since been identified as *D. infuscata* Sauss., by Werner (1935). The life-history account of *D. infuscata* Sauss. is given by Mathur (1934).

The incubation period occupied 15 to 18 days in the Punjab, during July-August. One egg-mass yielded 373 nymphs. The life-cycle appears to be annual.

Parasites and predators.—The wild egg-masses collected from various plantations have been found parasitised by a species of *Podagrion*. The number of parasites emerging from an ootheca varies considerably and the emergence may extend over several days. In many instances, two or three females have been observed to be depositing eggs in the same egg-mass at the same time. The oviposition process by *Podagrion* sp. is as follows: The parasite, on alighting on the egg-case, spends sometime in inspecting it with the antennae. She takes a firm position at a suitable place on the egg-mass, raises her abdomen, curls and brings her long and slender ovipositor underneath the abdomen. She pierces the surface of the egg-mass by the ovipositor by slowly depressing or moving from side to side her abdomen and buries the ovipositor deep towards the mantis eggs, while the sheath remains bent out behind. The egg is gradually pressed down from the abdomen through the ovipositor into the ootheca. After an egg has been laid, she partly withdraws her ovipositor and inserts again to lay another egg at a different angle. This process is repeated and thus several eggs are laid in one egg-mass. While ovipositing the female becomes completely absorbed in the act and is not disturbed when the egg-mass is handled for observations. The parasites escape by cutting small circular holes from the sides of the egg-mass.

The life-cycle of the parasite from egg to adult occupies 16 to 18 days in the Punjab plantations, during August. In the laboratory, females have been observed to oviposit in the egg-masses from which they have emerged.



1. Egg-mass of *Deiphobe incisa* Werner.
2. ,, *Hestiasula pictipes* Wood Mason.
3. ,, *Euantissa ornata* Werner.
4. ,, *Hestiasula brunneriana* Sauss.
5. ,, *Hierodula* sp. 1.
6. ,, *Hierodula* sp. 2.
7. ,, *Mantidae* sp.
8. ,, *Mantis* sp.
9. Egg-mass of *Parhierodula coarctata* Sauss.
10. ,, *Schizocephala* sp.
11. ,, *Tenodera superstitiosa* Fabr.
12. ,, *Tropidomantis guttatipennis* Ståt.

In addition to *Podagrion* sp., small species of Chalcidoidea, possibly hyper-parasites, have also been reared from the wild egg-masses. They have no long ovipositor.

Dermestids also damage the egg-masses in the laboratory and in the field.

In two instances, egg-masses were found torn to pieces apparently by some bird in order to get at eggs. The whole egg space was empty.

6. Euantissa ornata Werner.

(*EMPUSINAE*)

Distribution.—Dacca (Bengal); Tittimatti (Coorg); N. Salem (Madras); Dehra Dun (U.P.).

Life-history and habits.—This species is a common mantis at Dehra Dun during the summer months. At Tittimatti, it was found on teak (*Tectona grandis*) trees as predator on the larvae of *Hapalia machaeralis* Wlk.

Egg-mass (Fig. 3).—The egg-mass is pale clay yellow or biscuit colour, about 12–18 mm. long, 4–6 mm. wide and 4–6 mm. high. The attached surface is flat and the sides and both extremities are gradually sloping. The spongy surface is marked throughout by narrow and obscure, laterally oblique corrugations which indicate the successive position of eggs laid within the mass. The egg-mass has a long blunt projection posteriorly, while it terminates anteriorly in two gradually sloping irregular projections, which leave shallow spaces in between. The oothecae vary much in size and each egg-mass contains a variable number of eggs. A large egg-mass may contain 22 to 37 eggs while in small egg-masses the number of eggs may range from 12 to 18.

The reproductive capacity of five females is summarised as follows: One female mated twice and laid 4 egg-masses; two females, which mated only once, deposited 7 egg-masses each and the remaining two females also mated once and laid 9 egg-masses each. The egg-masses were laid at intervals of 4 to 8 days. In one instance, the last three egg-masses were incomplete.

The time taken in constructing the egg-masses also varies. The time recorded for the deposition of five egg-masses was 65, 50, 38, 30 and 20 minutes respectively. The egg-laying commences after 2 to 6 days from the time of mating. The egg-masses deposited by females in captivity were smaller than those taken outdoors and yielded reduced numbers of nymphs.

The egg-period occupies 19 to 26 days, with a mode of 21 days during July, August and September.

Nymphal stages.—The nymphs on hatching cast off their first skins, and are dark brown in colour. Two or three hours afterwards, they assume black colouration. The nymphs keep their abdomen horizontal and constantly vibrate their antennae and jump about actively when disturbed. The mature nymphs are

pale green, with head dark brown, tarsi light brown; prothorax, wing pads and abdomen tinged with lilac and violet carmine. The raptorial legs are held folded under the thorax.

The number of moults varies from 5 to 7 in this species. The second moult occurs after 9 to 16 days, with an average of 12·5 days; third moult after 8 to 20 days, with an average of 11 days; fourth moult after 5 to 15 days, with an average of 8·8 days; fifth moult after 5 to 9 days, with an average of 6·7 days; sixth moult after 5 to 7 days, with an average of 6·3 days; seventh moult after 9 to 12 days, with an average of 10·6 days.

The average nymphal period from the time of hatching to adult emergence, during summer, was 52·6 days, the longest period being 60 days and the shortest 42 days. The nymphal period of the overwintering generation was 210 to 266 days during 1934–35. One of the nymphs transformed into adult in November 1934, showing the nymphal period of 97 days.

Adults.—The adult mantids are very active and quickly fly away when approached. They constantly vibrate their antennae and at times extend their raptorial legs alternately, when at rest. The mates pair readily in confinement, but sometimes unsuccessful attempts are made by the males and the females do not respond. In such cases the male flies off quickly from the body of his partner. Copulation records show that six pairs remained coupled for 53, 50 (in two cases), 44, 30 and 15 minutes, respectively. The maximum and minimum life in captivity of the male mantids recorded was 104 and 34 days and that of the female mantids 84 and 19 days respectively.

Number of generations.—This species passes through two life-cycles in a year. In summer the total life-cycle from the deposition of an egg-mass to adult emergence occupies 63 to 81 days. The egg-masses laid in July-August hatch in August-September and the nymphs overwinter and transform into adults sometime in March and April next, indicating the total life-cycle of 236 to 285 days. In one instance, the nymph hatched on 4th August became adult on 9th November, revealing its total life-cycle of 117 days. In nature both nymphs and adults have been found during winter.

7. GONYPETA PUNCTATA HAAN.

(*MANTINAE*)

Distribution.—Recorded in January 1919 and February 1921 from Nilambur (Madras); in December 1941 and February 1942 from Nagerhole (Coorg); Madras. Malay; Sudan.

Life-history and habits.—This mantid is an extremely active creature and immediately flies away when approached. One adult male was captured while feeding on a half-mature larva of *Hapalia machaeralis* Wlk., in December 1941, from a teak tree.

8. Hestiasula brunneriana Sauss.

(*HYMENOPODINAE*)

Distribution.—Dehra Dun, Kalsi (U.P.); Nilambur (Madras); Sylhet (Assam); Ceylon.

Life-history and habits.—This is a small mantid having greyish green wings and the femora greatly expanded, bearing three marginal black spots and one black spot in the middle. The species is fairly common at Dehra Dun. The adults have been reported to feed on the caterpillars of *Hybloea puera* Cram., at Nilambur, Madras, in September 1925 (Mathur, 1934).

Egg-mass (Fig. 4).—The egg-mass is cream to biscuit colour and is variable in size, the largest being 17 mm. long, 5 mm. wide and 6 mm. in height. The anterior portion forms two arms which meet and terminate in a small, bent, truncated projection. Narrow, laterally oblique, obscure corrugations are visible on the spongy surface of the egg-mass. The bottom surface may be flat or slightly arched. Normally each egg-mass may contain 25 to 28 eggs. In small oothecae, the eggs may number 11 to 16.

In 1934, one female laid 5 complete egg-masses on 28th July, 2nd August, 15th August, 24th August and 26th August respectively, at intervals of 2 to 13 days; of which 3 contained fertilised eggs and 2 had unfertilised eggs. Another female deposited 3 complete egg-masses with fertilised eggs on 29th July, 7th August, 15th August and 2 incomplete egg-masses with unfertilised eggs on 25th August and 31st August respectively, at intervals of 6 to 10 days.

The incubation period occupies 24 days in May and 27 to 30 days in August-September. Practically, all the nymphs hatch the same day and during morning hours.

Nymphal stages.—The nymphs, on hatching, wriggle out and cast off their first skins which remain suspended on the ootheca. The young active nymphs are dark brown to black, with legs reddish brown banded with black; femora of forelegs expanded; tarsi of middle and hind legs greenish grey; penultimate abdominal segment ash grey dorsally, with a central black spot. The mature nymphs are dark brown in colour; head with a central projection or horn; thorax with black specks; femora of forelegs expanded having three marginal and one central black spots; middle and hind legs light brown banded with black; and tarsi greenish grey.

The nymphs keep their abdomen cocked up and vibrate their antennae constantly and jump about when disturbed. The raptorial legs are held folded under the thorax.

The number of ecdyses varies. During summer the nymphs undergo 6 or 7 moults. The second moult takes 12 to 15 days, with an average of 13 days; third moult 3 to 6 days, with an average of 5 days; fourth 5 to 7 days, with an

average of 5·83 days; fifth 7 to 9 days, with an average of 7·66 days; sixth 7 to 13 days, with an average of 10·83 days; and seventh 9 to 13 days, with an average of 11·4 days.

The average time from hatching to adult emergence was 48 days during summer, the longest period recorded being 53 days and the shortest 41 days.

Adults.—The adults are active creatures and extend their raptorial legs alternately in walking. The pair copulates readily when confined together in cages. One pair copulated for 3 hours and 57 minutes and another pair remained "in coitu" for 3 hours and 5 minutes. After copulation, one male was devoured by his female partner, and the other male escaped by jumping from the body of the female and ran for his life. Both the females laid their first egg-masses after 5 days of copulation. The construction of an ootheca is completed in about 45 minutes. Two females lived for 24 and 49 days and four males survived for 26, 38, 44 and 89 days respectively. The adults are sometimes attracted to light during August and September.

Number of generations.—This mantid appears to undergo two generations in a year. The summer generation occupied 65 to 77 days. The egg-masses were laid in May and the nymphs transformed into adults in July. These adults deposited oothecae in August and the nymphs when hatched overwintered. The second generation was not successfully carried through, as the nymphs died in February next.

9. HESTIASULA INTERMEDIA WERNER.

(*HYMENOPODINAE*)

Distribution.—Dehra Dun, Haldwani (U.P.); Buldana (C.P.); Fraserpet (Coorg); Madras; India.

Life-history and habits.—This species has been captured during May to December and is fairly common during June, July and August at Dehra Dun. Its egg-masses have been found on *Casuarina equisetifolia*, *Dalbergia sissoo*, *Shorea robusta* and *Tectona grandis.*

The egg-mass is about 10·5 mm. long, 6·5 mm. broad and 5 mm. high, pale buff in colour and convex in shape, with sloping sides.

The incubation period occupies 12 to 18 days between June-September. Each egg-mass yields 25 to 26 nymphs.

On hatching, the nymphs cast off their first exuviae which remain attached to the ootheca for sometime. The nymphs are dark brown in colour, having the femora of raptorial legs slightly expanded with black specks in the lower portion. They keep their abdomen raised and vibrate their antennae constantly. In summer the nymphs moult six times before transformation to adult stage. The second moult occurs after 8 to 9 days, third moult after 10 to 13 days, fourth moult after 9 to 10 days, fifth moult after 8 to 10 days, sixth moult after 13 to 26 days and seventh moult after 7 to 21 days.

The total nymphal period occupied 72 days during July, August and September 1935.

During winter of 1933–34 one nymph moulted eight times and the duration of the nymphal period was also prolonged. The nymph shed its second skin after 16 days; third skin after 20 days; and fourth after 30 days. It then over, wintered from November to February and recommenced moulting in early March, thus casting its fifth skin after 109 days. The nymph threw off its sixth moult after 30 days; seventh moult after 10 days and eighth moult after 12 days when it became adult in April. The total length of nymphal period occupied 227 days.

This species appears to pass through two generations in a year. One male lived for 80 days in captivity. The rate of feeding by this species, on the average, is one insect on every alternate day.

10. HESTIASULA PICTIPES WOODMASON.*

(*HYMENOPODINAE*)

Distribution.—Dehra Dun (U.P.), India.

Life-history and habits.—This mantid has been recorded during June, August, September and October at Dehra Dun. The species is very active and has got the habit of stretching and retracting its raptorial legs at times and also vibrating its antennae rapidly.

A female captured on 9th September 1936, laid 4 incomplete and infertile egg-masses on 14th, 16th, 21st and 22nd September respectively, and one complete ootheca on 23rd September. She died on 24th September 1936.

Another female caught on 28th September 1936, deposited 3 complete egg-masses on 29th September, 5th and 11th October, at intervals of 6 days. She took 45 minutes to complete an egg-mass.

In 1945, two nearly mature nymphs were captured on 13th August and reared to adult females on 21st August, in the laboratory. One female deposited four complete but infertile egg-masses, on 10th September, 24th September, 4th October and 16th October respectively, at intervals of 10 to 12 days. She died on 23rd October 1945. The second female also laid four complete and infertile egg-masses, on 10th, 17th, 24th September and 4th October respectively, at intervals of 7 to 10 days. She died on 29th October 1945.

The egg-mass (Fig. 2) is light pale buff in colour, about 10–12 mm. long, 4–6 mm. wide and 5 mm. in height; has a flat bottom and gradually sloping extremities. The anterior portion forms two short arms which meet and terminate in a small, bent, irregular projection. A shallow cavity is formed between the arms. The surface of the egg-mass is spongy and inconspicuously furrowed.

* My thanks are due to Dr. B. N. Chopra, Director, *Zoological Survey of India*, for supplying me the technical description of this species.

Two egg-masses yielded 11 to 17 nymphs, indicating the incubation period of 36 to 46 days during September and November, 1936. On hatching the nymphs wriggle out and cast off their first exuviae and move about actively near the egg-mass. All the eggs hatch simultaneously. All the nymphs died before reaching maturity by 2nd January 1937.

The young nymphs are dark brown to black in colour, with legs brown and the femora of raptorial legs expanded, with three distinct white spots in a longitudinal row.

11. HIERODULA SP. 1

(*MANTINAE*)

Distribution.—Arafwala, Changa Manga, Chichawatni, Dipalpur, Miranpur plantations (Punjab).

Life-history and habits.—This species is fairly common in the shisham plantations stated above. Its mature nymphs have been recorded in May and the egg-masses during June, July and August. The nymphs have been observed to feed on the larvae of *Plecoptera reflexa* Guen., in nature.

A nymph captured on 12th May from Chichawatni plantation moulted and transformed into adult female on 29th May 1939. She deposited an unfertilised egg-mass on 23rd June on a dry twig, and a second egg-mass on 13th July. She consumed two *reflexa* larvae of moderate size daily and died on 9th August. Another nymph caught from the same plantation on 19th May from *Acacia arabica* moulted twice and became adult on 9th June 1939, which survived for 8 days.

Several egg-masses, hatched and unhatched, were collected from various localities and were all variable in size. The egg-mass (Fig. 5) is pale buff in colour, about 30–32 mm. long, 13–15 mm. wide, and 12–13 mm. in height, with extremities tapering bluntly. The surface is spongy and very obscurely ribbed. The central top portion is slightly raised to form the scales and is of cream colour.

Two egg-masses collected on twigs of shisham on 17th July 1939 hatched after 7 to 9 days. The nymphs moult immediately on hatching, leaving their cast skins on the ootheca. The nymphs are pale green in colour and jump about when disturbed. Two nymphs moulted five times (excluding the first moult) between 26th July to 9th October and lived till 17th and 18th October 1939, *i.e.*, 83 to 84 days; while a third nymph moulted six times between 26th July to 12th October and survived till 22nd November 1939, *i.e.*, 119 days.

This species appears to undergo one generation in a year.

12. HIERODULA SP. 2

(*MANTINAE*)

Distribution.—Arafwala and Chichawatni plantations (Punjab).

Life-history and habits.—Two famales were collected from Chichawatni plantation and an unhatched egg-mass from Arafwala plantation, in July 1939.

Both the females deposited one egg-mass each, in captivity. One egg-mass failed to hatch while the other hatched after an incubation period of 18 days during July-August. 70 nymphs emerged from the egg-mass. A wild egg-mass yielded 100 nymphs after 17 days.

The egg-mass (Fig. 6) is grey with vacuolated surface, about 13–19 mm. long, 9 mm. wide and 5–7 mm. high, having sloping sides and blunt extremities. At the top is a narrow central ridge of scales which ends in a truncated point. The bottom surface is slightly arched or concave and the body is obscurely ribbed marking the position of the eggs deposited in the mass.

Soon after hatching the nymphs shed their first skins which remain suspended on the ootheca. The young nymphs are light pale greenish in colour and run about actively. Very few nymphs survived in transit when the material was brought to Dehra Dun. One nymph moulted seven times (second moult occurred after 11 days, third moult after 12 days, fourth after 5 days, fifth after 10 days, sixth after 10 days) during August-October and died on 23rd October 1939. Another nymph moulted four times only and survived till 28th October 1939.

13. Humbertiella ceylonica Sauss.

(*EREMIAPHILINAE*)

Distribution.—Plantations of Changa Manga, Chichawatni, Miranpur and Terah (Punjab).

Assam; Mandla (C.P.); Dehra Dun, Haldwani, Kalsi (U.P.); Travancore; India; Ceylon.

Life-history and habits.—This species is not common in the shisham plantations, Punjab and has been recorded in April, June, July and August. At Dehra Dun, its adults have been recorded in April, May, November and December. In nature, it is not known what insects it feeds upon. One female caught on 17th July 1940, at Changa Manga, laid two unfertilised egg-masses on 29th July and 15th August, respectively. In captivity, one female lived for 39 days during July-August; one male survived for 27 days during August-September and another male for 37 days during April-May.

This mantid has got the habit of vibrating its antennae constantly when at rest on the bark of trees. It comes to light occasionally, and one female was caught on 23rd June 1928 from Chichawatni plantation, and one male on 18th August 1939 from Miranpur plantation.

14. Humbertiella indica Sauss.

(*EREMIAPHILINAE*)

Distribution.—Recorded in April 1938 from Chichawatni and in April and July 1938 from Terah plantations (Punjab).

Bassein (Bombay); Nagerhole (Coorg); N. Salem (Madras). India; Ceylon.

Life-history and habits.—This mantid is occasionally found upon the bark of trees in shisham plantations, Punjab. The species is dull grey and is difficult to detect due to its colouration. When at rest, it vibrates its antennae constantly.

The adults were captured on *Tectona grandis* trees in Coorg during January and February 1942, which lived for 10 to 11 days in confinement.

15. Leptomantis indica Giglio Tos.

(*MANTINAE*)

Distribution.—Gauhati (Assam); Tittimatti (Coorg); Sikkim.

Life-history and habits.—This species is fairly common, both in the nymphal and adult stages, during November and December in the teak plantations of Coorg. The nymphs are very slim and light pale green in colour. The adults are active and immediately run for shelter to the underside of leaves or fly away when approached. In nature, both nymphs and adults have been observed to feed on young larvae of *H. machaeralis* Wlk., and small flies.

The wild nymphs captured in November-December, transformed into adults during next February and March, at the field insectary. Three caged adults lived for 4, 10 and 25 days respectively, under laboratory conditions.

This species comes to light occasionally.

16. Leptomantis parva Werner.

(*MANTINAE*)

Distribution.—Dehra Dun, Lachiwala (U.P.). India.

Life-history and habits.—Its adults have been recorded during September, October and November. One nymph was captured on 21st July and transformed into adult on 7th November 1934, indicating the partial nymphal period of 109 days. Two males lived for 29 to 53 days and two females 27 to 59 days, between September-November.

17. An Unidentified Species of Mantidae.

(*MANTINAE*)

Distribution.—Arafwala plantation (Punjab).

Life-history and habits.—An adult female mantid was captured on *Dalbergia sissoo* on 26th June 1938 from Arafwala plantation, and brought to Chichawatni insectary on 28th June, for further observations. She laid an egg-mass (Fig. 7) in the cage, on 29th June. The egg-mass is about 50 mm. long, 6 mm. wide and 5 mm. in height; irregular in outline, shining, silvery light gray in colour, broader at base and narrower at top. The surface is frothy and bears faint corrugations.

This egg-mass contained 47 eggs, which hatched in 17 days. The nymphs on hatching cast off their first skins and became free and active; but they

did not survive long and gradually all died. The female also died on 1st July 1938.

This species is light green in colour, with short elytra.

18. Mantis nobilis Brunner.

(*MANTINAE*)

Distribution.—Bhamo (Burma); Fraserpet (Coorg); Dehra Dun (U.P.); Sikkim.

Life-history and habits.—Recorded in June, July and August at Dehra Dun. On 24th June 1933, one adult male mantid was caught on a shisham tree, which lived in captivity till 7th July, on miscellaneous insects offered for feeding.

19. Mantis religiosa Linn.

(*MANTINAE*)

Distribution.—Coimbatore (Madras); Dehra Dun (U.P.); Africa; America; Asia; Australia; Europe.

Life-history and habits.—Recorded in September, November 1933 and again in November 1939, at Dehra Dun. One female was captured on 6th November 1939 from a shisham tree and laid an infertile egg-mass on 17th November. She died after 12 days.

The egg-mass is parasitised by *Podagrion pachymerum* Wlk., recorded by Ramaswamiah (1923) and Ramakrishna and Margabandhu (1934) from Coimbatore (Madras).

20. Mantis sp.

(*MANTINAE*)

Distribution.—Plantations of Arafwala, Chichawatni, Dipalpur (Punjab).

Life-history and habits.—One female mantid was caught on 7th June 1939 from a shisham tree and brought to the insectary at Chichawatni for further studies. In captivity, she consumed 2 to 3 caterpillars of *P. reflexa* Guen., of average size, per day. On 13th June, she laid an egg-mass on glass chimney and deposited two more egg-masses of smaller size, on a dry twig, on 18th June 1939.

Two males were also captured on 14th and 19th June 1939, from Chichawatni and Dipalpur plantations, respectively.

The egg-mass (Fig. 8) is pale clay yellow to light brown in colour and varies in size, from 18–25 mm. in length, 10–13 mm. wide and 7–11 mm. high, with upper surface convex and sloping extremities. The surface is spongy, slightly shining, obscurely furrowed and possesses a small, shallow cavity near the top anterior portion.

The egg-masses hatched after 14 days, yielding about 100 nymphs from the first egg-mass and only 15 nymphs from the smaller oothecae. Immediately on

hatching, the nymphs cast off their first skins, and the active nymphs are pale green with brownish tinge. Half mature nymphs are yellowish green.

The number of ecdyses in three individuals varied from 8 to 10. The second moult occurred after 8 to 11 days, with an average of 9·3 days; third moult after 3 to 11 days, with an average of 6·6 days; fourth moult after 5 to 16 days, with an average of 10 days; fifth moult after 7 to 12 days, with an average of 10 days; sixth moult after 7 to 8 days, with an average of 7·3 days; seventh moult after 7 to 10 days, with an average of 8·3 days; eighth moult after 4 to 16 days, with an average of 8·3 days; ninth moult after 5 to 26 days, with an average of 15·5 days; and tenth moult after 19 days.

The nymphal period occupied 71 to 84 days and the total life-cycle from the date of egg-mass deposition to adult transformation took 85 to 98 days, between June and September. One female from this generation laid an unfertilised egg-mass on 1st October 1939 and lived for 65 days, while another female survived for 44 days, under laboratory conditions.

This species appears to pass through two life-cycles in a year.

21. PARHIERODULA COARCTATA SAUSS.

(*MANTINAE*)

Distribution.—Plantations of Arafwala, Changa Manga, Chichawatni, Daphar, Dipalpur, Khanewal, Miranpur, Shahdara, and Terah (Punjab); Nowshera (N.W.F. Province); Shikarpur plantation (Sind).

Denkanikota, N. Salem (Madras); Dehra Dun (U.P.); India.

Life-history and habits.—This species is the most common mantid in the shisham plantations and has been observed to feed on the larvae and moths of *P. reflexa* Guen., *D. eridantis* Meyr., and *T. disputaria* Guen., in wild state. Its egg-masses, nymphs and adults have been collected on *Acacia arabica*, *Dalbergia sissoo* and *Prosopis spicigera*, during April, May, June, July and August. Chopard and Chatterjee (1937) have recorded this species on healthy sandal at Denkanikota. It is a green robust mantid and adopts a very frightening attitude or attacks the person concerned, when teased.

Its egg-masses (Fig. 9) and nymphs resemble *Hierodula westwoodi* Kirby the biology of which is described by Mathur (1934). One female laid two egg-masses within a period of 3 days. The wild egg-masses showed an egg-period of 11, 13, 16 and 18 days. The nymphs collected in April, transformed into adults in June and July.

This species appears to possess two cycles in a year.

Parasites.—The wild egg-masses yielded Chalcidoid parasites and Dermestids,

22. Parhierodula venosa Ol.

(*MANTINAE*)

Distribution.—Tittimatti (Coorg); Coromandal, N. Salem (Madras). Asia.

Life-history and habits.—Previously known from Jawalagiri, N. Salem, on healthy sandal (Chopard and Chatterjee, 1937). Recorded in October 1940, at Coorg. This species is long, robust and green, and becomes very furious when teased.

23. Schizocephala sp.

(*MANTINAE*)

Distribution.—Plantations of Arafwala, Chichawatni, Dipalpur, Khanewal and Makhdumpur rakh (Punjab).

Life-history and habits.—This mantid is fairly common at Chichawatni plantation and is generally found on bushes, *Capparis aphylla*, grass, shisham coppice and *Zizyphus jujuba.* The egg-masses, nymphs and adults have been recorded during June, July and August.

An egg-mass deposited by a female on 25th June 1938, hatched on 18th and 19th July, showing an incubation period of 24 to 25 days. Another egg-mass laid on 28th July 1939, by a female captured on 19th July, hatched on 23rd August, after 26 days. One female caught on 18th July 1940, laid an incomplete egg-mass on 28th July and another complete ootheca on 2nd August. The nymphs hatched after 36 to 38 days, during August-September. Some wild egg-masses collected during July-August 1938 and 1939, indicated partial egg-period of 10 to 23 days.

The egg-mass is invariably deposited on a small twig, and is secured by a ring formed by the gummy secretion at the bottom hind end, while the remaining bottom portion of the egg-mass forms a groove round the twig. When laying an egg-mass, the female at first forms a ring round a twig with her gummy secretion and then she continues to deposit one egg on either side alternately in the frothy secretion. One female took one hour and 45 minutes in completing an egg-mass.

The egg-mass (Fig. 10) is light yellowish brown, having the hind and dorsal portions dark brown, about 20–23 mm. long, 5–6 mm. thick and 7–9 mm. high, and terminates in a converging point anteriorly. The surface is frothy and obscurely ribbed indicating the position of eggs, and encloses a clear transparent space near the anterior portion. The number of eggs laid in an egg-mass varies from 30 to 65.

The nymphs moult immediately on hatching, and are light fawn in colour and pale yellow laterally. The eyes are conical and situated in front of the head, and the antennae are small and pale yellow. The nymphs are tender and jump about when disturbed.

The adults are very long, greenish brown in colour, having long slender legs and short wings folding tightly round the body. They are slow in movement

and blend nicely with their surroundings and are difficult to detect. One female lived for 32 days, under laboratory conditions. In nature, the adults have been observed to feed on *reflexa* larvae.

This species appears to possess one annual life-cycle.

24. STATILIA MACULATA THUNB.

(*MANTINAE*)

Distribution.—Chichawatni plantation (Punjab); Shillong (Assam); Nagerhole (Coorg); Dehra Dun, Kalsi (U.P.). Asia.

Life-history and habits.—Recorded in June 1919, August and November 1922 from Dehra Dun; in May 1938 from Chichawatni plantation; and during December 1941, January, February 1942 from Coorg, on teak trees. This mantid is very active and matches the colour of the bark and thus escapes detection. The adults lived for 5 to 20 days in laboratory.

25. TENODERA SUPERSTITIOSA FABR.

(*MANTINAE*)

Distribution.—Chichawatni, Dipalpur, Khanewal, Shahdara and Terah plantations (Punjab).

Pusa (Bihar); Dehra Dun (U.P.). Africa.

Life-history and habits.—This mantid is not very common in the shisham plantations, Punjab, and has been recorded in June, July, August and September. In nature, it has been noted to feed on the larvae of *P. reflexa* Guen.

The egg-masses have been found laid on the twigs of shisham and bushes, and are variable in size; a large egg-mass measures about 10 mm. in length while the smaller one is about 4 mm. long. They are nearly 5 mm. wide and 7 mm. in height. The attached surface is either flattened or more frequently shallow concave. The colour of the egg-mass is light buff and is darker near the top grooved area. The surface is prominently ribbed and the top anterior end is produced into a long spine-like process which may be about 10 mm. long (Fig. 11).

The egg-masses contain variable number of eggs, and in 10 egg-masses, the number of eggs counted were 5, 7, 7, 9, 9, 11, 11, 13, 13 and 17. One female laid 11 small egg-masses in the laboratory at Terah.

The incubation period lasts 13 to 16 days during April-May and August. On hatching, the nymphs cast off their first skins which remain attached for sometime on the egg-mass. The young nymphs are active, brownish green, having legs banded with dark brown bands; head produced into a bifurcated tubercle and antennae very short, with segments broader at base and narrower at apex.

One mature nymph caught from Khanewal plantation on 14th July 1938 transformed into adult on 28th July.

On 26th August 1939, the field insectary was closed down and the breeding of the nymphs hatched from the egg-mass laid on 7th August by a wild female from Shahdara, was continued in insectary at Dehra Dun. The nymphs moulted thrice by mid October and lived till mid December when they all died due to intense cold.

The longevity of the females from the time of capture was 46 days during April-June 1938, at Terah, 52 days during August-September 1938 at Chichawatni, and 7 days in August 1939 at Shahdara.

26. TROPIDOMANTIS GUTTATIPENNIS STÅL.

(*MANTINAE*)

Distribution.—Nagerhole, Tittimatti (Coorg); N. Salem (Madras); Himalaya; Tibet; Tonkin.

Life-history and habits.—Previously recorded on sandal from Coorg and Madras (Chopard and Chatterjee, 1937). This species is common in the teak plantations of Coorg and all stages occur during the winter months. Both nymphs and adults are predaceous on the young lârvae of *H. machaeralis* Wlk., and *H. puera* Cram., in nature. In captivity, the nymphs feed on 1–2 young caterpillars, while the adults devour one mature *machaeralis* larva, on the average per day.

Egg-mass (Fig. 12).—The egg-mass is pale clay yellow with faint silvery reflection, elongate-fusiform in shape, with bottom surface flat. The egg-masses are variable in size; a large egg-mass measures 28 mm. by 2 mm. and contains 41 eggs, while the smaller ones measure 20 mm. by 1·5 mm., and contain 19 eggs. The surface of the egg-mass is obscurely marked by laterally oblique furrows which indicate the position of eggs deposited within the mass. One female constructed an egg-mass in about 47 minutes. The egg-masses are generally found laid on the leaves and occasionally on the bark.

One female captured on 19th November 1941, deposited 5 fertile egg-masses on 1st, 20th, 30th December 1941, 8th and 22nd January 1942 respectively, at intervals of 9 to 19 days. She died on 27th January 1942. Another female caught on 20th November 1941, laid 4 fertile oothecae during November-January, at intervals of 9 to 28 days.

The incubation period occupied 24 to 38 days during November 1941 to February 1942.

Nymphal stages.—Immediately on hatching, the nymphs cast off their first exuviae, which remain suspended on the egg-case. The young nymphs are slim, pale or dull white in colour having light black transverse bands on antennae and legs. Mature nymphs are less active, very slender built and light pale green in colour. In captivity, majority of the nymphs died while moulting and only few survivors were reared to the adult stage during end of March and April. The exact number of moults undergone by this species is not known. The nymphal development took 74 to 101 days, under laboratory conditions in Coorg.

In nature, the nymphs when full-fed, lie flat on the leaves and remain in this position throughout the day and at dusk they move to the underside of the leaves.

Adults.—The species is light green and very active in the adult stage. The maximum life of the adult recorded is 69 days and the minimum 10 days during November-April, in captivity.

Parasites.—The wild egg-masses yielded small Chalcidoid parasites.

LIBERATION OF MANTIDS AND THEIR RECOVERIES

Batches of nymphs of *Deiphobe incisa* Werner, totalling about 3,870, were sent by post during July and August 1938 from Chichawatni to Miranpur plantation where its presence was doubtful. Twenty to fifty per cent. mortality occurred in transit. Two batches, constituting about 2,365 nymphs, were also despatched by post to Miranpur plantation from Dehra Dun when about 50 per cent. mortality occurred in transit. The living nymphs were released in compartments where the defoliation was heavy and the *shisham* defoliator was in abundance (Beeson, 1941). In 1939, releases of this species were not made, but hatched egg-masses were recovered in May, July and August 1939.

Similarly, in Arafwala plantation, about 200 young nymphs and 47 egg-masses of *D. incisa* Werner were introduced on 25th July 1939. The nymphs were released in coupes where the defoliator was in abundance. The egg-masses were caged in small tin containers, punched with holes for the escape of nymphs on hatching and hung on to shisham branches. The hatching was very successful from these egg-masses.

In 1938, 2 females, 2 males and one egg-mass of *Parhierodula coarctata* Sauss., were released on 23rd July and 1 female and one egg-mass of the same species were sent on 29th July, by post, to Dipalpur plantation. The material reached there in safe condition. Again during 1939, an egg-mass laid in insectary on 13th June, was introduced on 17th June. About 300 and 100 young nymphs were despatched by post on 14th and 15th July, respectively. Four females (adults) and four egg-masses deposited in insectary were released on 21st July. One egg-mass and 5 half mature nymphs (2 males and 3 females) were liberated on 14th August.

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BIOLOGICAL OBSERVATIONS ON *TRYPANEA AMOENA* FRFLD.

By K. N. TREHAN, M.SC. (PUNJAB), PH.D. (LONDON)

Agricultural Entomologist to Government, Bombay,
College of Agriculture, Poona

I. INTRODUCTORY

Various species of the family Trypetidae are of economic importance in different countries where a considerable amount of fruits is damaged and rendered unfit for human consumption. The larvae, as a rule, are responsible for the damage and may possess a variety of habits such as (1) living in fruits, (2) living in flowers, (3) mining leaves and (4) making galls. The first two types are of general significance whereas, *Dacus cucurbitae* Coq., the well-known fruit fly of India and *Ceratitis capitata* Wied., the Mediterranean fruit fly, are of particular importance as they attack practically all succulent fruits and vegetables.

II. DISTRIBUTION AND FOOD PLANTS

Trypanea amoena is a serious pest of flower heads of various plants and is widely distributed. Bezzi (1913) recorded it for the first time from Calcutta and Lahore and later (1924) from Ethopia. Efflatoun (1924) regarded this species as the commonest pest of its genus in Egypt, infesting the flower heads of the family Compositae. Hendel (1927) recorded this species from Europe, Canary Islands, North Africa, Persia, Central Asia, Philippines and Formosa. The Imperial Pusa collection at New Delhi includes a specimen of *T. amoena*, bred from galls in the stem of *Vernonia cineria* at Pusa in 1927. Aczel (1937) recorded this species as a serious pest of *Lactuca sativa* in Hungary while Niblett (1939) mentioned its occurrence in England.

The author observed *T. amoena* as a serious pest of marigold at Lyallpur (Punjab) during March and April and again of Chrysanthemums during November and December. The information at hand shows that the species is confined to plants of the family Compositae.

III. NATURE OF DAMAGE AND THE INCIDENCE OF ATTACK

The infested flowers are quite conspicuous by their malformation and bad opening. In such cases, the majority of the ray-florets cluster in the middle and practically form a cone. The maggots, as well as the pupae, are found almost embedded at the base of the thalamus formed by the disk-flowers. Each infested flower may harbour 1–9 of these stages. The Pusa records indicate that this species is capable of forming galls on the stem but this requires further confirmation.

During March and April 1939, 615 apparently malformed flowers of marigold were examined from various gardens and 251 maggots and puparia of *T. amoena*

were recovered. On an average, 40·8 per cent. of such flowers harboured the immature stages of the pest. During this period, the maggots were almost full-grown but were fewer in number than the pupae. Adults were not met with in nature, but quite a number of them emerged in the laboratory from the pupae collected from the fields. Repeated attempts to breed the insect under captivity proved unsuccessful.

Numerous other flowers of Compositae and of other families, which were growing side by side with marigolds, were examined but none of them was found to be infested.

Similar observations were made during March and April 1940, but no stage of *T. amoena* could be observed in nature. During November, 1940, however, some flowers of Chrysanthemum, round about the Agricultural College estate (Lyallpur), indicated malformation and bad opening. When examined, some of them were found to harbour puparia of *T. amoena* from which adults emerged in the laboratory. In all, 529 such flowers were examined which yielded 29 pupae and 3 full-grown maggots. The seasonal activity of the pest deserves further investigation but it may be presumed that its active period in the Punjab extends over winter and spring months only.

IV. Brief Notes on Available Stages

Only full-grown maggots and puparia were obtained from the fields.

Maggot.—The full-grown maggot is creamy white and almost barrel-shaped. The mouth parts or the sclerites are very prominent, deep black in colour and in the living insect embedded in the thalamus and operating like a needle.

Pupa.—The puparium is ovoid and of the coarctate type. To begin with, it is almost white but soon after a few brown rings are developed on both the ends. These rings develop further till the entire puparium changes to deep black.

Adult.—The emergence takes place by the fly cutting open a cap at the narrower end of the puparium. The adults, which emerged in the laboratory, were sluggish but very attractive in appearance. A short description of the adult is given below since the original description of the species is not easily available:

Head yellowish, face short, eyes relatively large and dark red in colour, epicranium broad. Antennae short, three segmented, the basal two segments being concolorous with the head, third segment dark brown, concave inwards, arista prominent, practically bare; palpi yellow, brownish apically. Legs brown, front femur with conspicuous bristles on the outer side. Wings elongate, costal margin with series of minute bristles, a pair relatively larger at the base of the stigma; veins yellow, darker distally, the main veins disposed almost parallel to each other; stigma yellow, triangular; basal $\frac{2}{3}$ of the wing hyaline, unspotted; blade with dark brown pattern running from costal to hinder margin but the

patches separated by small hyaline spaces, about 10–12 in number; halteres white, almost transparent. Abdomen grey or dark grey covered over with whitish prominent pubescence; ovipositor elongated, black and slightly broader at the base.

V. Parasites

Some maggots were found parasitized by Chalcid parasites. Each parasitized maggot had one or two parasite grubs on its body. From the parasitized material collected from fields, two types of parasites were bred out. Both the species were sent to Dr. Ferriare of the British Museum, London, who considered them as new species, one of the genus *Dimeromicrus* (Torymidae) and the other of *Habrocytus* (Pteromelidae). Their descriptions will be published separately.

VI. Acknowledgement

The author expresses his gratitude to Dr. Khan A. Rahman, Entomologist, Agricultural College, Lyallpur, for the facilities provided when the investigation was in progress at that station. He is also indebted to Sir Guy A. K. Marshall, Director, Imperial Institute of Entomology, London, and Dr. C. H. Ferriare of the same institute for the identification of the species and to the Imperial Entomologist for supplying some information connected with it.

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LIFE-HISTORY AND BIONOMICS OF CASTOR SEMI-LOOPERS IN HYDERABAD (DECCAN)

By MOHAMMED QADIRUDDIN KHAN, M.SC., PH.D. (LONDON), D.I.C.

Entomologist, Agriculture Department, H. E. H. the Nizam's Government, Hyderabad (Deccan)

I. INTRODUCTION

The castor plant, *Ricinus communis,* is cultivated as a *kharif* crop in dry lands. The area under castor cultivation in the Hyderabad State alone is estimated at a little more than half a million acres, producing about 50,629 tons of castor seed per annum. It is subject to the attack of a number of insects, such as, semi-loopers, loopers, hairy caterpillars and other leaf-caterpillars, white flies, capsule borers, etc. Of these, the semi-loopers are the most destructive, comprising two species observed in this area, *viz.*, *Achaea janata* Linn. and *Parlellia algira* Linn. An attempt is made here to give a summary of the work done on the life-history of *A. janata* and *P. algira*. These two pests, in spite of being very common and serious, do not appear to have received sufficient attention so far, and the available information on them is rather scanty. The few papers published are mostly by Lefroy (1908) and by Ayyar (1935 and 1942).

II. THE PEST AND ITS OCCURRENCE

Eggs of castor semi-looper's moth are generally found in the middle of May on perennial castor plants. Caterpillars in all stages of growth occur in the first week of June. July and August are the months of activity, when 4–5 eggs may be observed on every castor leaf. In August, September and October, outbreaks of this pest are quite common in the castor areas. From November onwards, the activity of the pest decreases and no serious outbreaks occur. After the harvest of the crop in March, stray caterpillars are found on perennial castor plants in April, May and June.

III. NATURE AND EXTENT OF DAMAGE

The first instar caterpillars nibble only the outer tissue of the leaf. The second instar catterpillars damage the leaves by making holes; the third and the fourth instar caterpillars completely defoliate the leaves. In the case of a very bad attack, whole fields of castor are defoliated and sometimes even the stems are attacked and destroyed.

IV. NUMBER OF GENERATIONS

Five to six generations of this pest are passed in a year in Hyderabad–Deccan. The first generation is observed late in June and early July, the second in August and the third in September. Due to heavy rains during this period, the broods

are not regular. The fourth generation is noted some time in late October and early November. From November onwards, stray caterpillars are found in the fields and it is not possible to determine exactly the periods of the fifth and the sixth generations. In Hyderabad, the second and third generations are very serious and the attack is very heavy during August and September. In some places of Nalgonda and Mahboobnagar districts serious outbreaks have been noted in October and November also.

V. LIFE-HISTORY

The following account refers to both the species but where differences exist they have been indicated:

Pre-oviposition.—The pre-oviposition period varies from 6–21 days in June and July, and lasts for about 21 days in September and October.

Egg.—The eggs are laid singly on either surfaces of the leaf. More than six eggs were never recorded on a single leaf. The eggs are green in colour. The egg-shell is full of ridges and furrows. Its upper surface is convex and lower concave. It is about 0·9 mm. in diameter.

Eggs of *A. janata* are slightly bigger than those of *P. algira*. The striae in the eggs of former are deep and numerous. The incubation period lasts for 3–4 days. The larva emerges out by cutting a hole at the side of the egg.

First Instar Caterpillar.—The young larva before emergence lies in a spiral form inside the egg-shell. It emerges by cutting a small hole on the lateral side of the egg when it measures about 4 mm. in length. It has not been observed eating the shell. The head capsule is chitinous and slightly brown. The anterior one-third portion of the body is light green and the posterior region light brown. On the dorsal surface there is a median line of bristles, and on lateral regions there are 3 rows of bristles. On the ventral surface the nerve ganglion is quite visible in each segment through the transparent skin. The ommatidia in the caterpillars of *P. algira* are not so close as in *A. janata*. The first instar lasts for 2 days.

Second Instar Caterpillar.—The second instar caterpillar measures about 7 mm. in length. The head is almost black with a few white patches. There is variety of colours in the caterpillars of this stage. The tubercles on the anal hump are quite distinct. On the lateral region dull red and blue stripes are fairly distinct. Each segment, on either side, has got a dark brown or black spot.

The larva of *P. algira* is greenish. It is thinner and less active than that of *A. janata*. There is a large black circle on either side situated in the 4th segment. This stage lasts for 2 days.

Third Instar Caterpillar.—The third instar caterpillar measures about 4·8 cm. in length. The colour varies from brown to black. In the second and third stages the larva has two pairs of tubercles, one situated on the thoracic segment and the other on the anal. The tips of the anal tubercles are deep red.

The colour of the *P. algira* larva is dull light brown, which is maintained throughout. This period also lasts for 2 days.

Fourth Instar Caterpillar.—The fourth instar larva of *A. janata* measures about 2½ inches. The thoracic tubercles are very prominent. The caterpillars are stout and capable of doing great damage. Colouration in the caterpillars is discussed below under a separate heading.

P. algira caterpillar is also about 2½ inches or 5 cm. in length. At the posterior margin of the head capsule there is a pair of large light yellow spots and another pair of smaller spots is situated in front. In *A. janata*, besides these spots there is another large patch on either side. Yellow stripes lying on the epicranial sutures are double in *A. janata*. The light brown mid-dorsal chain is distinct. The caterpillars are of uniform colour. On the ventral surface there is a mid-ventral thick stripe running almost all along the body. This band is darker at the bases of the legs. The outer surface of the pro-legs is yellow, whereas their inner surface red. The skin of the caterpillars is thin and wrinkled. Thoracic legs are also red in colour. There are small white dots on the pro-legs provided with tubercles. Thoracic tubercles are absent, and this portion is marked out by the presence of some black markings. This period lasts for 5–7 days in *A. janata* and 9–12 days in *P. algira*.

The larval period in *A. janata* varies from 12–13 days and in *P. algira* 15–18 days. The first 3 instars are of equal duration, and the last one is longer than the first three taken together. There is one more stage between the 4th instar and the pupa which may be regarded as the pre-pupal stage the period of which lasts for 2–3 days, both in *A. janata* and *P. algira*. During this period the caterpillar shrinks and shortens and lies in inverted S form. It is about an inch in length. It covers itself with leaves when on the plant, or with sand when in the soil. Later on, it spins a silken cocoon. During this final moult the larval skin which breaks at two points, head and thorax, is thrown away. The ashy coating on the body of the developing pupa is observed only after 18 hours and sometimes after 36 hours.

Colouration in the Caterpillars of A. janata.—The caterpillars of *A. janata* show a great variety of colours and patterns. They can be divided into four varieties when they are in the 3rd and 4th stages. In the earlier stages it is not possible to group them owing to the diversity of forms in colours.

(I) VARIETY A

The caterpillars of this group have thick black velvet-like dorsal stripes lying between the dorsal yellow streaks. On the lateral side between the two lateral lines running parallel from the anterior end to the posterior end of the insect body the colour is brick red. Small round black spots lie in one line in this area. The general colour of the caterpillars is almost pale red.

(II) VARIETY B

The caterpillars of this group are lighter in colour in comparison to those of the other groups. The dorsal lines are yellow and quite distinct. In between the dorsal lines there are black spots on the mid-dorsal region, which is the speciality of this group. Sometimes these spots join together and give an impression of a mid-dorsal streak.

(III) VARIETY C

The caterpillars of this group are velvety black and appear as soft as velvet. The dorsal and lateral streaks are not continuous. On the lateral sides the spots are very small in size and dark in colour.

(IV) VARIETY D

The caterpillars are light black in colour with a pair of longitudinal streaks, yellowish in colour, and sometimes a third is also present, but it is usually broken. The spots on the lateral sides are very small in size. All the four varieties are quite common in Hyderabad.

Pupa.—The size of the pupa depends upon the sex. The length of the male pupa of *A. janata* varies from 1·9–2·1 cm., and breadth 0·6–0·8 cm., and length of the female pupa from 2·0–2·5 cm. and breadth 0·7–0·8 cm. The length of *P. algira* pupa varies from 2–2·4 cm. and breadth 0·55–0·65 cm. Male and female pupae of this species are almost equal in sizes. The pupal case of *A. janata* is chitinous and covered up with some ashy matter which is absent in the pupa of *P. algira*. The anal segment is provided with four pairs of hooks, which are hooked on to the silken cocoon. The 5th and 6th abdominal segments are free in both sexes. In both sexes there is a pair of pro-leg scar on the seventh abdominal segment. The genital opening is slit-like and is situated on the 8th abdominal segment in the female and on the 9th in the male. The pupal case breaks in V-form and the moth emerges out from the anterior region.

The pupal period in dry weather is short, whereas in the cold weather it is slightly longer. Increase or decrease in the life-history periods of *A. janata* or *P. algira* depends mostly on this period. The pupal period in *A. janata* varies from 11–27 days, and that in *P. algira* from 11–24 days.

Moths.—The size of *A. janata* moth is 60–65 mm. and of *P. algira* 40–45 mm. The characters of the moths in both cases are practically the same as described by Hampson (1894). The following additional information is also of some interest.

A. JANATA

Dull brown, dull black. In some moths the ante-medial and post-medial wavy lines are double, but the latter have got some black suffusion in side, chiefly at the distal end of the wing. In some moths the medial band of the fore-wing is white and in some slightly reddish. In some moths this band is reduced to a line only.

Sex Differentiation.—Hampson (1894) makes no mention in his description whether the characters refer to either male or female.

The sexes can be easily distinguished by the examination of the last abdominal segment and the frenulum on the anterior margin of the hind wing, both in *A. janata* and *P. algira.*

The anal segment in both the species is provided with a brush-like tuft of scales to conceal the male genitalia, whereas in the female this tuft is absent and the anal segment is small and more conical. The anterior margin of the hind wing near the base is provided in the male with only one frenulum in both the species unlike the female where there are two. In the male of *A. janata* the markings of the fore-wing are usually prominent. The dirty white patches lying between the ante-medial and post-medial wavy lines are quite distinct. The lines and various shades in the scales of the fore-wing are quite distinct. In the female these markings and lines are almost obsolete due to dark brown coloured scales.

Total Developmental Period.—This period is shorter in June, July and August lasting for about 28 days in *A. janata* and 31 days in *P. algira.* From October onwards this period increases, and in February and March it is about 47 days in *A. janata* and 49 days in *P. algira.* From March onwards it was not possible to make observations, as the crop was harvested and in the laboratory it was too hot to rear them.

Alternate Host Plants.—A. janata and *P. algira* caterpillars feed on rose, pomegranate, *Bauhinia* sp., *Ziziphus, Ficus bengalensis* and *Euphorbia tilulifera.*

VI. Natural Enemies

The eggs of both species are parasitised in the field by *Trichogramma evanescens* Westw., race *minutum* Riley.

The 2nd instar caterpillar of both *A. janata* and *P. algira* are heavily attacked by *Microplitis maculipennis* (Szep). The life-cycle of this parasite lasts for about 7 days. Two more larval parasites, *Rhogas* sp. (Braconidae) and *Euplectrus* sp. (Eulophidae), were also noted in the fields. The former attacks only caterpillars of *A. janata* and the latter both the species.

VII. Acknowledgements

I am thankful to Dr. H. S. Pruthi, formerly Imperial Entomologist, New Delhi, for his kindly identifying the parasites and to Rao Bahadur Kalidas Sawhney, Director of Agriculture, Hyderabad-Deccan, for providing many facilities.

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A NEW SPECIES OF *URANOTAENIA*, CULICIDAE-DIPTERA FROM HYDERABAD (DECCAN)*

By M. QUTUBUDDIN, M.SC.

Entomologist, Medical Department, Hyderabad–Deccan

During a survey of the culicine mosquitoes of Hyderabad (Dn.) city, the author came across a few males and females of the genus *Uranotaenia* which differed in certain external features not only from the Indian species, described by Barraud (1934), but also from those mentioned by Edwards (1922). A thorough study of the external features of diagnostic importance showed that the male genitalia differed from known species in the form and shape of style, which has great diagnostic value and also differs from species to species in the genus *Uranotaenia*. A camera lucida drawing of the style is given in Fig. 1. I dedicate this new species to the veteran Indian Entomologist, Mian Afzal Husain, of Lahore, who happened to be the General President of the Indian Science Congress, 1946, at which session this paper was read.

One type specimen, male, and one allotype are deposited in the Indian Museum and several co-types are retained in the Laboratory of the Chief Malaria Officer, Hyderabad–Deccan.

Uranotaenia husaini sp. n.

A fairly large brown species, abdomen with dark dorsum and pale brown venter, thoracic pleurae of conspicuously yellow colour, rather white.

Female.—Head covered with numerous dark brown flat scales with a line of pale brown somewhat creamy scales to the eye-margins. Vertex mainly dark and covered with numerous brown upright fork-scales. Clypeus, palps and proboscis dark brown. Palps very short, projecting only very slightly in front of clypeus.

Thorax.—Integument of mesonotum dark brown covered with narrow dark brown scales and numerous long curved bristles. There is no thin line of narrow white scales along margin of mesonotum from wing roots nor any white thin scales forming a line in front of the mesonotum; postnotum dark brown; pleurae uniformly pale brown, upper part of sternopleurae slightly darker in colour. Anterior postnotum yellowish, posterior postnotum brown. A few flat pale scales on sternopleurae and posterior postnotum. *Wings* entirely dark-scaled. *Legs* dark-scaled, devoid of ornamentation. Segment I of hind tarsi shorter than tibia.

Male resembles female except for plumose antennae.

Hypopyguim style different in shape from other species (Fig. 1).

* This paper was read at the 33rd Session of the Indian Science Congress Association, held at Bangalore, in January 1946.

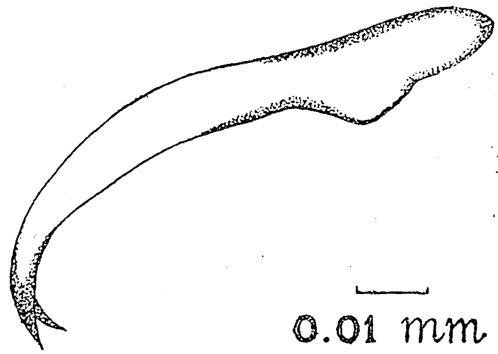

FIG. 1. *Uranotaenia husaini*, sp. n. Male hypopygium—style.

Larva, pupa and egg.—Unknown.

Habitat.—Caught from crab holes near seepage pools where no pitcher plants were to be seen.

This species is quite distinct from all the ornamented species in having wings, legs, abdomen, and mesonotum completely devoid of any ornamentation. The uniform yellowish white colour of the pleurae distinguishes it from all the Indian species including *Uranotaenia hebes* which has pale brown pleurae. From *U. nivipleura* it is readily distinguished by the absence of a thin line of narrow white scales along margin of mesonotum from wing roots continued round the front, as also by the extremely short palpi of the female. The palps in *U. nivipleura* are twice as long as the clypeus. It cannot be confused with *U. novobscura* Barr., because of the pale venter of the former. From *U. subnormalis* Mart., it is quite distinct due to the absence of a group of stiff bristles on the first hind tarsal joint of male. It differs from *U. nivipes* Theo., in the absence of a broad band of white flat scales round margin of mesonotum. The dark brown colour of the mesonotum distinguishes it at once from *U. moultoni* Edw. and *U. brevirostris* Edw. Distinguished from *U. unimaculiala* Leic. and *U. argyrotarsis* Leic., by the coloration of the wings and legs.

The shape of the style in male hypopyguim separates it from the Indian as well as the oriental species.

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CHRYSOPA CYMBELE BANKS AND ITS TWO NEW VARIETIES

By M. M. NASIR
Indian Agricultural Research Institute, New Delhi

While carrying out studies on the biology of the most common species of Chrysopids (*C. scelestes* Banks) met with in Lyallpur, the writer collected *Chrysopa cymbele* Banks in large numbers from cotton fields of the Lyallpur Agricultural Farms predating upon *Bemesia tabaci* and *Empoasca devastans.* This species was previously collected from Madras, Salem division and Jawalgari by Ayyar and described by Banks [1933, *Indian For. Rec.*, **18** (6): 3]. A detailed study of all the specimens was made and the writer was able to separate out two new varieties described hereunder on the basis of absence or presence of a fuscous stripe and not exactly red as described by Banks (*l.c.*).

Chrysopa cymbele *Banks* (Figs. 1, 2).—General body colour green which changes to pale yellow after sometime in pinned specimens; mid-dorsal streak aurora-yellow. Basal joints of antennae, palpi and frons unmarked; clypeus along the epistomal suture and on side with a fuscous band. Wings greenish, venation likewise fading to pale colour in dried specimens, unmarked, acute at tips; gradates of forewing in parallel rows, the inner series comprising of 6–7 and the outer as well the same number. Outer row nearer to the margin than to the inner. Divisory veinlet ends at or near the cross vein above; second cubital cell as long as the third; and closer to the radius. Hind wings unmarked, gradates 4–6 in each row. Stigma in both the wings somewhat conspicuous. Wing expanse 2·1–2·3 cm. by 2·45–2·65 cm.

The above description is based on the specimens nos. 12 (3–8–1939), 67 (10–9–1940), 3 (3–8–1939) and 65 (4–8–1940) collected from cotton fields of the farm.

Third stage larva (Fig. 5).—Head light yellow with two blackish converging lines arising from the bases of antennae and reaching the hind margin of head, a second pair of shorter and thinner lines, one each on the outer side and parallel to the above, also reaching the hind margin and a third very short divergent pair in the middle arising from the anterior part of head as figured. Mandibles, antennae and palpi red at tips and light red at the base. Prothorax light yellowish with anterior portion white; heart reddish. Prothorax with 2 black and 2 red lines, meso- and meta-thorax with black dots and red lines. Legs translucent white, black at the joints; setae 9–10 in number and hooked at ends to carry host skins. Body length 0·7 cm.

Chrysopa cymbele *var.* **a-fasciata** *var., n.* (Fig. 3).—The variety is easily distinguished by the absence of black stripe along the epistomal suture and sides of clypeus; otherwise similar to *C. cymbele.*

Type: Specimen No. 11 (3–8–39).

Allotype: Specimen No. 22/14 (3–8–39).

Paratypes: Specimen Nos. 16 (17–9–40), 21/14 (11–8–40), 26 (3–8–39), 62 (24–8–40), 25/14 (11–8–40), 64 (3–9–39), 13 (10–8–40), 14 (9–9–40), 63 (3–9–40).

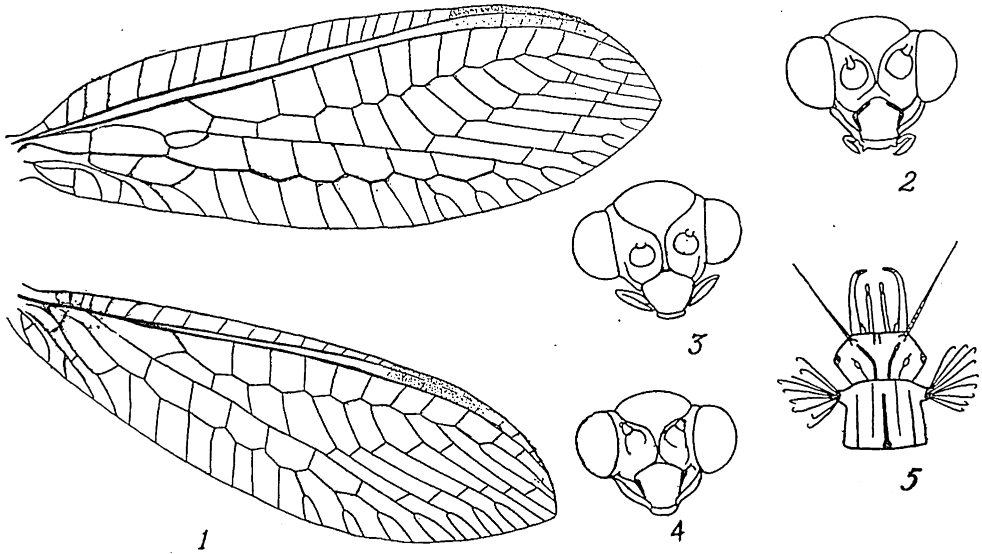


Fig. 1. Front and hind wings of *C. cymbele* × 11. Fig. 2. Frontal view of the head of *C. cymbele* × 18. Fig. 3. Frontal view of the head of *C. cymbele* var. *a-fasciata* × 18. Fig. 4. Frontal view of the head of *C. cymbele* var. *fasciata* × 18. Fig. 5. Dorsal view of head and prothorax of 3rd. instar larva of *C. cymbele* × 30.

Chrysopa cymbele *var.* **fasciata** *var. n.* (Fig. 4).—In this case the fuseous stripe is present only along either side of cylpeus but does not extend to the epistomal suture. In other respects it resembles *C. cymbele.*

Type: Specimen No. 19/13 (11–8–39).

Allotype: Specimen No. 60 (12–8–39).

Paratypes: Specimen Nos. 61 (27–8–40), 20/13 (11–8–40), 17 (28–8–40), 21/13 (3–9–39).

The type specimens of the above varieties have been deposited in the Pusa Collection, Indian Agricultural Research Institute, New Delhi.

The author identified the species as *Chrysopa cymbele* Banks and checked the identification at the Forest Research Institute, Dehra Dun, in 1943, through the courtesy of Mr. J. C. M. Gardner. Again in 1945, the same specimens were sent to Dehra Dun, when their identification was confirmed by Messrs. A. H. Khan and G. D. Bhasin, to whom my thanks are due.

LARVAE OF CANTHAROIDEA (COLEOPTERA)

By J. C. M. GARDNER

Forest Research Institute, Dehra Dun, U.P.

The larval characters of the superfamily Cantharoidea and of the contained families are discussed by Boving and Craighead (1931) and by Emden (1932) who treats the group as a family (Cantharidae) with a number of sharply defined subfamilies. Some authors refer to the group as the Malacodermata and to the Cantharidae as Telephoridae.

Three families, Cantharidae, Lycidae and Lampyridae are represented by larvae in the collection of the Forest Research Institute, Dehra Dun.

Larval Characters of the Cantharoidea.—Without a distinct articulated labrum. Mandibles falcate, adapted for sucking liquids, with a longitudinal groove, or an internal channel, or split longitudinally into two parts. Maxillary articulating area reduced. Legs with five parts, the last a single claw.

Key to families

1. Mandibles very slender, with bases closely approximated medially, each cleft longitudinally (Epicranial halves not meeting ventrally) .. .. *Lycidae*

   Mandibles with normal lateral articulation, not cleft (2)

2. Mandibles with more or less open groove. Epicranial halves meeting ventrally. Certain segments with paired glands .. .. *Cantharidae*

   Mandibles with closed longitudinal channel. Epicranial halves not meeting ventrally. Body without paired glands .. .. *Lampyridae*

CANTHARIDAE

Larvae elongate, narrowing towards extremities, without urogomphi (cerci). Head with epicranial halves fused ventrally and forming a broad bridge which is emarginate anteriorly. One ocellus on each side. Mandibles sickle-shaped, with a longitudinal groove along inner surface. Maxillary palp with four segments. Body soft, with dense velvety pubescence; the segments with paired glands. Frontal sutures not distinct. The larvae are primarily carnivorous, feeding on soft bodied larvae but certain species are recorded to have fed on wheat grains in captivity.

Tylocerus lividus Hope

Larva (Fig. 1).—Head brown, darker behind the middle; body smoky brown above with paired paradorsal darker marks on the three thoracic segments.

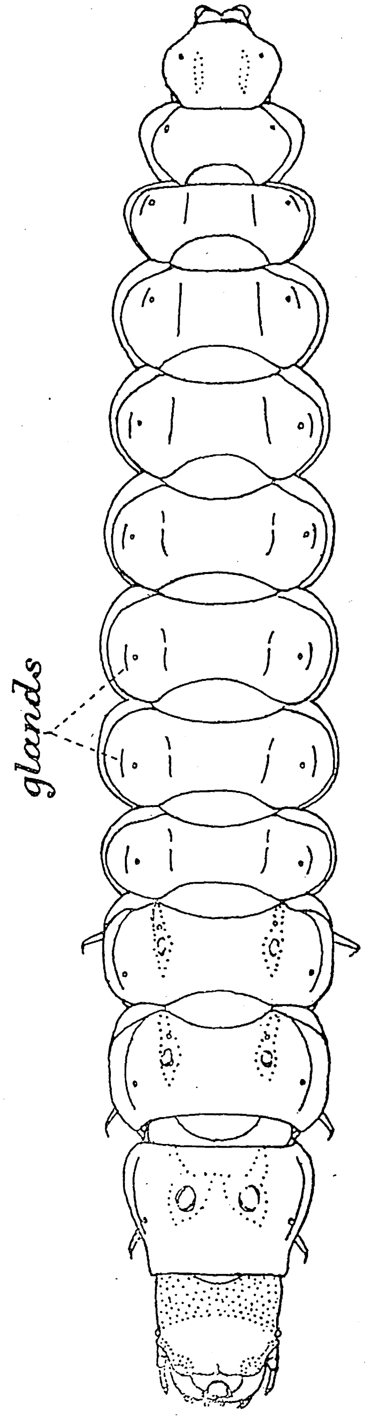


FIG. 1. Larva of *Tylocerus lividus* Hope, dorsal view.

Head with the ventral bridge about one-half as long as head; emarginate posteriorly above and below. Anterior dorsal margin (nasale) slightly sinuate, crenulate on each side of a small median projection; behind the anterior margin, on the epistomal surface, is a complex structure, part of which consists of two transverse medially broken rows of teeth. Antenna with three segments, the first slightly wider than long; the second about twice as long as wide, not produced apically; the third small, distinctly longer than wide and rather longer than the sensory appendage. Mandible with longitudinal groove fringed by fine setae; retinaculum strong, subacute; there is a slight obtuse convexity at base of retinaculum but no distinct tooth. Maxillary palp with first and third segments transverse, the third rather longer than wide, the fourth rather stout, conical; galea well developed, elongate, apparently with one segment (or with a small subdistinct basal subdivision). Labial palp with stout basal segment which is slightly longer than wide and a much shorter elongate conical apical segment. The paired tergal glands appearing as small circular spots showing a complex symmetrical radial pattern. Length about 16 mm.

Six larvae were found while flooding a lawn in Dehra Dun in August. The larvae were floating on the surface of the water and were prevented from becoming wet by a film of air held by the close pubescence. Two beetles were reared and were identified by Dr. K. G. Blair. Adults of this species were noticed visiting flowers of *Vitex negundo*.

LAMPYRIDAE

Larvae.—Mandible sickle-shaped, perforated by longitudinal channel, with retinaculum. Head with distinct frontal sutures; epicranial halves not meeting ventrally. One large ocellus near each antennal fossa. Maxillary galea with two segments. Abdominal spiracles situated in epipleurites. Anal segment with retractile processes. Larvae with light-organs.

The larvae feed on snails and slugs. A fluid injected into the mollusc through the perforated mandibles apparently breaks down the tissues which are then imbibed in liquid form, a group of thick hairs preventing the passage of solid particles of any size.

Key to Species

1. Terga of thorax and of first eight abdominal segments each with four blunt protuberances along posterior margin; their posterolateral angles variably pointed .. .. *Luciola dubia*
   Terga with even posterior margins .. .. (2)
2. Mandible and its retinaculum very slender and acute. Penultimate segment of maxillary palp strongly transverse, the last elongate, the palp with four segments .. .. *Diaphanes planus*
   Mandible moderately slender, retinaculum rather blunt. Penultimate segment of maxillary palp elongate, large and claviform, the apical segment very small; the palp with only three apparent segments .. .. *Lamprophorus tenebrosus*

Lamprophorus tenebrosus Walk.

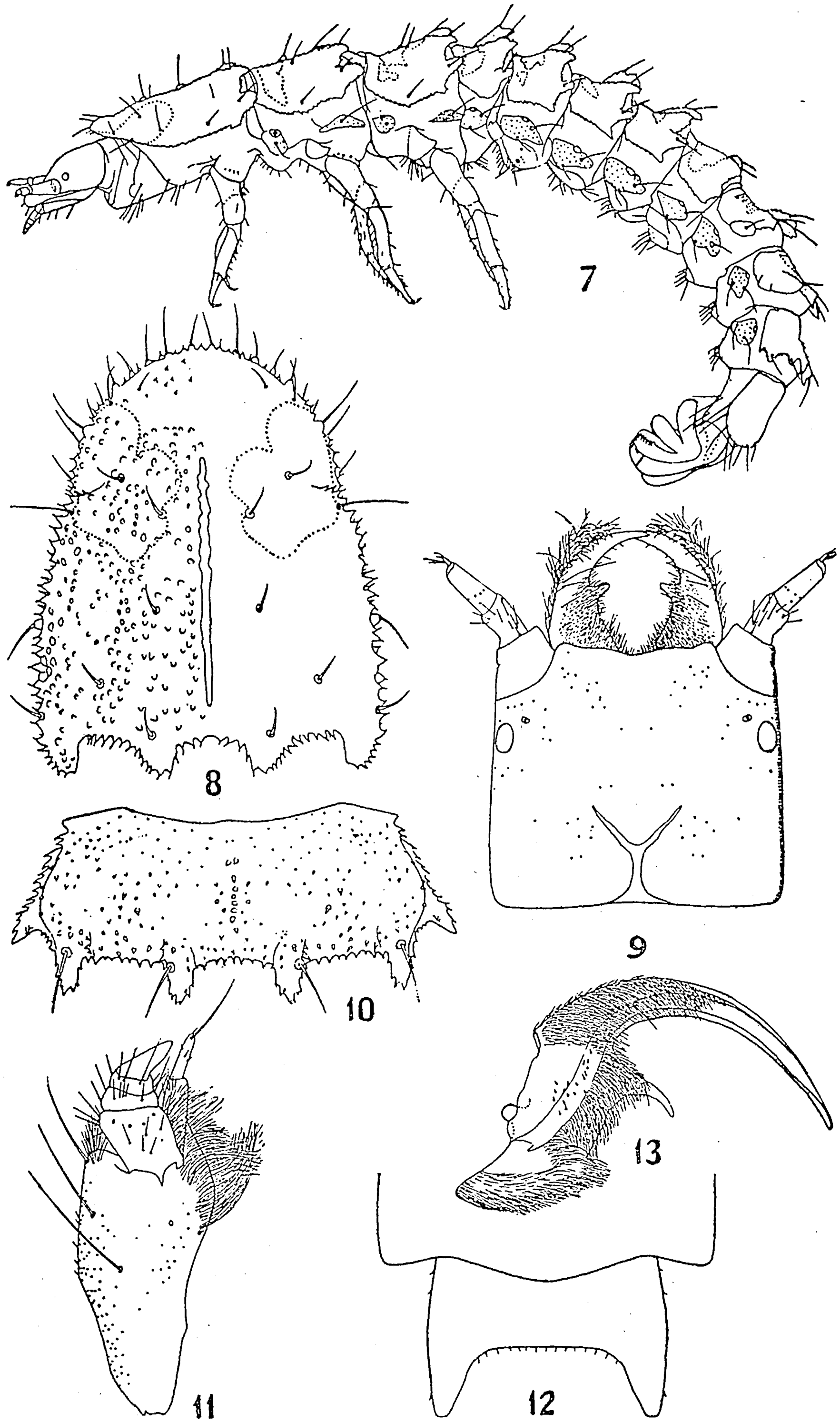
Larva.—Dark castaneous above, the margins of the terga testaceous; pronotum also with a pair of testaceous streaks anteriorly. Body more or less parallel sided, narrowing to extremities. Tergal plates extending laterally considerably beyond underlying parts of the body.

Head parallel-sided, a little wider than long. Coronal suture extremely short. Frontal plate acutely emarginate anteriorly. Antennae with a very long narrowly cylindrical basal segment (attached to head by a strongly developed soft-skinned part); the second segment is much shorter, longer than wide and bears a minute pointed apical segment. Mandibles with blunt retinaculum. Maxillary palp apparently with only three segments, the first transverse, the second very large, fusiform or subclavate, the third small and subglobose. Labial palp with rather large cylindrical basal segment which is much longer than wide, and a very small tapering apical segment.

Body terga flat, extended laterally, without projections, margined laterally, surface slightly rugulose; posterior margins nearly straight on anterior segments, widely emarginate on posterior segments. Pronotum wider than long. Sternal plates with stout bristles. Length of larva 60 to 65 mm.

Several larvae were found in a mound of earth, Dehra Dun (J. C. M. G.); a beetle was reared from a pupa taken at the same time.

An interesting account of the life-history and larva of this species is given by Paiva (1919) and the mouth parts are discussed by Raj (1943).



FIGS. 7–13. Larvae of Lampyridae.—7. *Luciola dubia* Ol., lateral view. 8. *L. dubia* Ol., onotum. 9. *L. dubia* Ol., head, dorsal view. 10. *L. dubia* Ol., 3rd abdominal tergum. *Diaphanes planus* Gorh., maxilla. 12. *D. planus* Gorh., caudal extremity. 13. *D. planus* ıh., mandible.

Luciola dubia Oliv.

Larva (Figs. 7–10).—Head, tergal plates (except an anterolateral pale area on each side of pronotum), a triangular plate on prosternum, and coxae dark castaneous; underside and remainder of legs pale.

Head with short coronal suture; anterior margin of frontal plate nearly straight. Antennae with second segment much longer than first; the third small and longer than wide. Mandibles moderately slender, the retinaculum subacute, not recurved. Maxillary palp with basal segment longer than wide, the second and third (which is narrower) moderately transverse, the fourth elongate and tapering. Labial palp with subglobular basal segment and longer, slender apical segment.

Terga granulate, the margins denticulate; each of the first eleven terga with four rounded to subacute projections along the posterior margin; the posterior lateral angles dentate. The pronotum longer than wide, narrower at the rounded anterior margin; the following ten terga transverse. The ninth abdominal tergum longer than wide with rounded posterior margin, without marked projetions. Length about 14 mm.

Larvae were found in weed on the banks of a stream, Dehra Dun (J. C. M. Gardner, 952); a beetle was reared.

A figure of *Luciola gorhami* Rits., given by Fletcher (1919, *Agric. Res. Inst., Pusa, Bull.*, **89**: 28, fig. 21), shows a strong resemblance to *L. dubia*.

Diaphanes planus Gorh.

The following notes are based on exuviae of reared beetles.

Larva.—General colouration dark brown; the large ocellus of each side enclosed in black. Antennae elongate, the distal segment small, elongate-cylindrical. Mandibles (Fig. 13) strongly curved, fine and acute distally; retinaculum acute and recurved. Maxillary palp (Fig. 11) with basal segment large, nearly as wide as long; second and third segments very short, strongly transverse; fourth elongate, tapering. Galea with two elongate segments. Labial palp with subglobular basal segment and with a longer slender tapering apical segment. Body widest at thorax gradually narrowing posteriorly. Pronotum longer than wide, narrowing to the rounded anterior margin; following terga transverse. All terga simple, without protuberances, the posterior margins straight or slightly sinuate except the posterior one (Fig. 12) which has a pointed projection from each posterior angle. Length of larva about 14 mm.

Two pupae with larval skins were found in a rotten tree-stump, Darjeeling [(J. C. M. G.) (see also Raj, 1943: 276)].

LYCIDAE

Larvae (Figs. 2–6).—Epicranial halves completely separated ventrally. Mandibles each cleft longitudinally into an inner needle-like part which fits into

a groove in the outer part; the bases of mandibles approximate medially. One ocellus on each side of head. Antenna with two segments, the first strongly transverse, the second stoutly cylindrical, with an apical obtuse soft area. Maxillary stipes and mentum not separated by sutures. Frontal sutures absent. Maxillary palps three-segmented and borne on a segment-like palpifer; galea one-segmented (vestigial in *Calochromus tarsalis*). Labial palps two-segmented.

Larvae of Lycidae are commonly found in numbers under loose bark of decaying trees and logs where they probably feed on fermenting juices; Withycombe (1926, *Proc. Ent. Soc. Lond.*, page 32) shows that the larva of *Calopteron fasciatum* F. feeds on fermenting juices exuded from decaying *Erythrina* logs.

Key to larvae

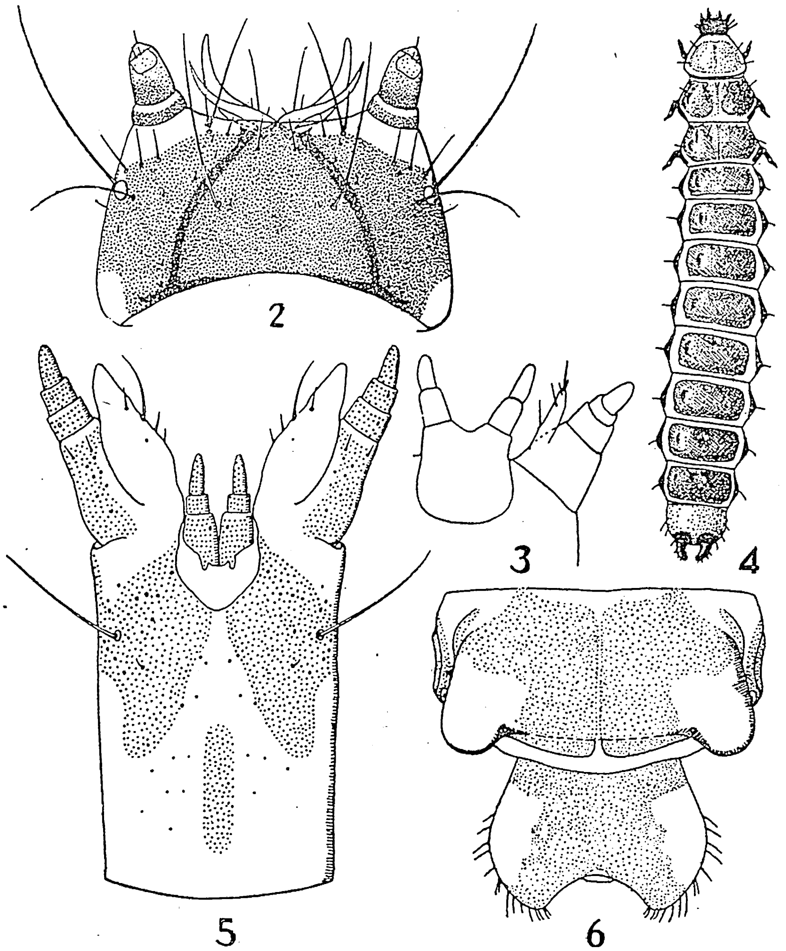
1. The three thoracic terga widely extended laterally far beyond the underlying parts; abdominal segments with a slender laterad process on each side; "trilobite larvae" .. .. *Lyropaeus biguttatus*
   Thoracic terga not widely extended .. .. (2)
2. Abdominal terga with abrupt projections or elevations on lateral margins .. .. .. (3)
   Abdominal terga flat, not raised laterally .. .. *Calochromus* spp.
3. Thoracic and abdominal terga with a subacute caudad projection on each side, except A 9 which is simple, with convex hind margin. Head and pronotum both transverse. .. .. .. *Plateros* sp.
   Thoracic terga not raised laterally; first eight abdominal terga with a rounded tubercle on each side. Ninth tergum deeply emarginate posteriorly. Head and pronotum both longer than wide .. *Lycostomus similis*

Calochromus

Larvae (Figs. 2–4).—Head transverse. Terga of body flat, not projecting laterally. Ninth tergum with two stout, apically obtuse urogomphi which are unarticulated, inset from margins of the tergum, and incurved. Body more or less fusiform. Prothoracic and ninth abdominal tergum yellow at least in part; the intervening terga dark brown, sometimes yellow medially. The maxillary mala rather short and slender or vestigial. Larvae in groups in small pockets in rotten tree trunks.

Key to species

1. Maxillary palpifer about as long as wide. Maxillary mala slender and distinct. Urogomphi rather long. Length about 15 mm. Kashmir; United Provinces (Chakrata) .. .. .. *C. kashmirensis* Kleine
   Maxillary palpifer transverse .. .. .. (2)



FIGS. 2–6. Larvae of Lycidae.—2. *Calochromus tarsalis* Wat., head in dorsal view. 3. *C. darjeelingensis* Bourg., labium and left maxilla. 4. *C. kashmirensis* Kln., dorsal view. 5. *Lycostomus similis* Hope, ventral mouth parts, ventral view. 6. *L. similis* Hope, caudal segments, dorsal view.

2. Maxillary mala distinct. Urogomphi moderately long (Body usually with a medio-dorsal yellow line). Length about 18 mm. Bengal (Darjeeling) *darjeelingensis* Bourg.

   Maxillary mala vestigial. Urogomphi very short and stump (T_2 and T_3 yellow medially; A 1 to A 8 usually dark brown). Length 22 mm. United Provinces (Almora) .. .. *C. tarsalis* Wat.

Plateros sp.

Larva.—Light brown above, lateral margins of terga darker.

Head wider than long, narrowing gradually posteriorly. Maxillary palpifer long, conical, longer than the three-segmented palp; mala reaching to near apex

of palp, rather slender. Labial palp with both segments elongate, the distal one very slender. Pronotum wider than long, following terga more strongly transverse. The lateral margins of the terga (except A 10) raised into a rather slender subacute projection directed backwards and slightly upwards. The terga do not project laterally. The 10th segment directed caudad and visible from above, narrow, with simple weakly convex posterior margin. Length about 9 mm.

Two larvae together with a beetle and its exuviae from rotten wood, Dehra Dun, U.P. (J. C. M. G.). The beetle was determined by Herr Kleine as *Plateros* sp.

Lycostomus similis Hope

Larva (Figs. 5–6).—Terga dark brown, the postero-lateral angles yellow except on A 1 which is entirely brown and on A 9 where there is a yellow spot on each side anterior to the caudal projections; sclerotised lateral and sternal plates dark brown.

Head distinctly longer than wide, nearly parallel-sided. Maxillary palpifer longer than the palp of which the two basal segments are transverse, the third longer than wide; the maxillary mala large, subconical, extending about to apex of second segment of palp. Labial palp with basal segment transverse, the second longer and slender. Pronotum distinctly longer than wide, narrowing to anterior margin, broadly rounded and not raised at the posterior angles. Mesothorax and metathorax rather wider, the posterior angles also rounded. Abdominal terga 1 to 8 transverse, not extended laterally over remainder of body, the postero-lateral angles raised into a strong rounded tubercle; tergum A 9 transverse, convex laterally and widely concave posteriorly, the lateral angles obtusely projecting caudad. The surface of the terga irregular and with a more or less distinct transverse prebasal ridge. Length about 24 mm.

Four larvae and a beetle (with its exuviae) under bark of a log, Kurseong, Bengal (N. C. Chatterjee).

Lyropaeus biguttatus Gorh.

The larva of this species has been described and figured by Gravely (1915, *Rec. Indian Mus.*, **11**: 358, pl. 22, figs. 1–12).

The thoracic terga are very wide, projecting laterally far over the underlying body; rectangular, slightly more than twice as wide as long. Abdominal terga 1 to 8 each with a finger-like projection directed slightly caudad. A 9 with a projection from each lateral angle. Abdominal sterna with a pair of small conical processes on posterior margins.

In two larvae (on bark, Kalimpong, Bengal) which I take to be this species, the head is longer than wide; the stout maxillary palp is about as long as the three segments of the maxillary palp together, and the large, more or less conical mala extends to about the apex of the palp. Larva blackish brown. Length about 18 mm. Gravely's specimens were found under a large slab of stone in Cochin.

REFERENCES

BOVING, A. G. AND CRAIGHEAD, F. C., 1931, *Ent. Americana*, **11** (Keys down to families or subfamilies of beetle larvae).

EMDEN, F. VAN, 1932, *Bull. Ann. Soc. ent. Belg.*, **72** (A key to families allied to Cantharoidea is given on page 205).

PAIVA, C. A., 1919, Notes on the Indian glow-worm (*Lamprophorus tenebrosus* Wlk.), *Rec. Indian Mus.*, **16**: 19.

RAJ, J. S., 1943, Mouth parts of *Lamprophorus tenebrosus* Wlk., *Current Science*, **12** (3): 83.

————, 1943, External Morphology of the larva of the glow-worm, *Diaphanes* sp., *ibid.*, **12**: 276.

SHORT NOTES AND EXHIBITS

Record of *Euzophera cocciphaga* Hampson as a predator of the Fluted Scale, *Icerya purchasi* Maskell.

During the course of a survey for the well known pest *Icerya purchasi* Maskell in peninsular India, the author noticed it on casuarina trees at Krishnarajasagar in Mysore State. A closer examination of the attacked branches and the white fluted egg masses of the scale revealed the presence of a predaceous caterpillar feeding on the eggs. It was found that the caterpillar feeds on the eggs inside the ovisac of *Icerya purchasi* and when full grown, after spinning a silky cocoon,

White masses made up of the fluted egg sacs of Cottony Cushion Scale, *Icerya purchasi*, in which the caterpillars of *Euzophera cocciphaga* pupate after feeding on the eggs of the scale insect.

pupates there. Externally the cocoon is thus protected by the empty fluted ovisac made up of the white cottony wax secretion of the scale insect. Such large white masses (see photograph) formed by this caterpillar were seen in large numbers on the branches and the pest appeared to be considerably controlled. Moths reared from these caterpillars have been identified as *Euzophera cocciphaga* Hampson. This species has been reported by Ayyar as effectively checking the

multiplication of *Aspidoproctus xyliae* Green (MS), but this is the first time that it has been found feeding on the fluted scale. The actual use of this predator in the control of the pest has yet to be ascertained.

The moths of this species reared by the author were identified by the Imperial Entomologist. The author is deeply indebted to him for the help.

New Delhi. V. PRABHAKER RAO.

Factors affecting the development and time of hatching of eggs of *Drosicha stebbingi* Green.

There are great variations in the time of hatching of the eggs of the mango mealy bug, *Drosicha stebbingi* Green in different provinces and also at different places in the same province. Variations also occur in the same locality in different years. The main causes for these variations are the temperature and humidity of the soil at a particular time brought about by early or late monsoon rains, winter showers and digging of the ground underneath the mango trees. If there be no disturbing factors after rainy season to create ununiformity in the gradual decrease in the humidity and temperature of the soil, hatching may take place towards the end of November. On the other hand, late monsoon rains and winter showers very much delay the hatching. By digging the ground, the surface soil loses moisture quickly and becomes cooler than unworked soils. If the digging is done in November, by which time development of embryo inside the egg shell is complete, the sudden change brought about in the environment hastens the hatching of the eggs and facilitates the emergence of nymphs from the ground. But digging of the ground during or soon after monsoon, when the eggs are in their early stages of development, may destroy many of the eggs, as has been observed in the case of the eggs of apple root borer, *Dorysthenes hugelii* Redt., which are also deposited in the ground. When the latter are exposed to abnormal conditions in the early stages of their development, almost all of them die, but this exposure does not affect the fully developed eggs except that it hastens hatching. There appears to be some possibility of controlling the pest by making some changes in the time of routine digging. One digging soon after the rainy season to destroy the undeveloped eggs and another about the middle of November to hasten hatching of the surviving eggs at a time when there is nothing much on the mango trees for the newly hatched nymphs to feed on may minimise damage by this pest.

Cawnpore. R. N. SINGH.

NEW BOOKS AND MONOGRAPHS

A Catalogue of the Parasites and Predators of Insect Pests.—Prepared under the direction of W. R. Thompson, F.R.S., by the staff of the Imperial Parasite Service. Section 1. Parasite Host Catalogue. Part 1. Parasites of the Arachnida and Coleoptera. 1943, pp. ix+151. Part 2. Parasites of the Dermaptera and Diptera. 1943, pp. iv+99. Part 3. Parasites of the Hemiptera. 1944, pp. iv+149. Part 4. Parasites of the Hymenoptera, Isopoda and Isoptera. 1944, pp. iv+130. Part 5. Parasites of the Lepidoptera (A–CH). 1944, pp. iv+130. Published by the Imperial Agricultural Bureaux, Institute of Entomology, Parasite Service, Belleville, Ont., Canada.

The catalogues have been issued in mimeographed form and in five volumes, each volume being assigned to a Part. In a general introduction in Part 1, Dr. W. R. Thompson states that 'the biological method of controlling insect and plant pests is still, scientifically, in its infancy' and though recent studies have shown the problems of parasite behaviour to be more subtle and difficult than previously imagined, they have also indicated them to be full of practical possibilities. He explains briefly the principles underlying the biological method of pest control and the means which may be adopted to exploit the latter to practical advantage. It is perhaps the experience of most agricultural Entomologists that many pests, both insect and plant, are naturally kept under check during many years by their insect and other animal enemies but the manipulated employment of these enemies against pests has not been free from difficulty and even failure. Nevertheless, some spectacular successes have been achieved in several parts of the world though there have been some dismal failures also. It is, therefore, up to the economic Entomologist to study the behaviour and other aspects of the parasites and predators of insect pests and even of insects, not pests but closely allied to the pest species, and assess their value in biological control. In this task the catalogues, issued by the Imperial Parasite Service, should prove invaluable.

The catalogues give the recorded (and, in some cases, the unrecorded) specific names of the parasites and predators of the various host species of the orders, dealt with in them, together with the names of the countries of record and appropriate references to literature, as available till the 31st December 1937. Further records appearing subsequently are promised as supplements. Much of the information given is based on the papers, noticed in the *Review of Applied Entomology*, but, where a paper was consulted in original, its own, full reference is included. At the end of all the catalogues, except Part 5, which is yet to be completed, there are lists of 'Host synonymy not shown in the text' and alphabetical indices of the parasites mentioned in them. The method of using the catalogues to maximum advantage is fully explained in the Introduction to each Part.

One has only to read through some parts of the Catalogues, even at a sitting, to appreciate the difficulties with which Dr. W. R. Thompson and his collaborators must have been faced in the matter of insect nomenclature for the purposes of the catalogue and of which they speak on page v of the Introduction to Part 1. ". . . . the most satisfactory method in bibliographical compilations of this type", states Dr. Thompson, "is to record the names as they appear in the original references." This is what has been done in the Catalogues but Entomologists are warned to sift the records carefully before making further use of them. The last but one paragraph of the Introduction to Part 1 deserves to be quoted in full.

"This catalogue is merely a guide to the recorded relationships of parasites and predators, compiled from literature. Entomologists should not accept the records without consulting the original papers because their factual value is variable and uncertain. Indeed, some of the records included are, in the opinion of the experts consulted and of the Editor, definitely wrong. However, the exclusion of such references would not be justified, since the object of a bibliography is simply to put the user in contact with the sources."

K. B. Lal.

Crop Pests in the United Provinces and their Control.—By K. B. Lal, M.Sc. (Alld.), Ph.D. (Edin.), Entomologist to Government, U.P., Cawnpore. Published by the Department of Agriculture, U.P., in the 'Grow More Food' series and as a Plant Protection (Entomology) Bulletin No. 1—1946. 49 pages. Price four annas. Obtainable from the Superintendent, Government Printing and Stationery, Allahabad, U.P.

The plan and the object of the Bulletin are stated on its first cover page as follows:—"This Bulletin presents information on twenty-eight major insect pests and on rats, injuring field crops in the United Provinces, for the first time in a consolidated form. It does not deal with the insect pests attacking fruit trees vegetable crops, ornamental and garden plants and stored products. In it, short descriptions of the pests, to aid in their easy recognition in the field, brief accounts of their life and seasonal histories, and practicable methods of their control are given in a form to be readily understood by the non-entomologist. Figures of the stages of the pests, commonly met with, are also given. Five appendices at the end add useful information to the Bulletin. The object of this Bulletin is to help in the production of *more* and *better food* by giving information which may be utilised in checking damage to field crops caused through insect attacks."

Insect Pest Number.—By Khan A. Rahman, B.Sc. (Edin.), Ph.D. (Cantab.), F.R.E.S., Entomologist, Punjab Agricultural College, Lyallpur.—*The Punjab Agricultural College Magazine*, Vol. VII, Nos. 5–7, May–July, 1940, iii+iii+98 pp.

Having had an occasion recently to scrutinise the formula of a repellent, given in the above publication, my attention has been drawn to a whole series of mistakes and mis-statements occurring in it, which remains even after allowing

for the 2-page errata accompanying it. As the publication has been and may still be in use by agricultural and other students, it seems desirable, even at this date, to correct certain of the mis-statements and, in particular, to discuss a control measure recommended against the walnut weevil.

In the Preface, the author gives the history of the Entomology Section of the Punjab Agricultural College and rightly praises Mr. M. Afzal Husain for the progress which Entomology had made under his guidance in the Punjab. It is, however, an exaggeration to claim that "many insect pests of the Punjab can now be controlled cheaply and effectively". There are more serious pests for which cheap and effective remedies are not available than those which can be cheaply and effectively controlled. It is stated that "a large volume of very valuable information was amassed" about several, important insects by Mr. Afzal Husain and his staff "about which nothing was previously known". Further, the author says that ". . . . the credit of acquiring original information . . . . belongs to K. B. M. Afzal Husain; I have merely compiled this information from his various writings. . . ." It should have been graceful if similar acknowledgements had been made in the case of several other publications of this author.

The author's claim that his "Figures are original" is not justified, unless it is merely meant that the figures were simply redrawn for his publication. This will be a new use of the word "original", as applied in scientific literature. As a matter of fact most of the figures are copied. For instance, figure 19 reminds one of the coloured plate of *Papilio*, issued by the Imperial Agricultural Research Institute. Figure 22 is undoubtedly from the memoir by Afzal Husain and Dina Nath. The unnecessary appearance of the numeral 7 unmasks the truth. Various other figures of insects and equipment can be easily recognised and traced to published entomological literature.

We now come to an extraordinary formula which appears on page 88. Recommending a repellent for the walnut weevil, *Alcides porrectorostrus* Marshall, the author says on page 58, "To prevent the female from laying eggs, trees should be sprayed once every ten days beginning from May, with lime-copper sulphate-paris green-solignum mixture (paris green to be used in the first two sprays only)." It is not stated as to how long this spraying operation is to continue. The same procedure is recommended for the fig borer, *Batocera rufomaculata* De Geer. On page 54, the author says: "To prevent the females from laying eggs . . . . the stem of the plant . . . . should be sprayed five times with lime-copper sulphate-paris green-solignum mixture". The formula of this mixture, as given on page 88, is as follows:—

Lime	8 seers
Copper sulphate	1 seer
Paris green	4 chhataks
Solignum	4 chhataks
Water	16 gallons

Lime and copper sulphate are repellents. In Bordeaux mixture, which acts as a repellent, 3 lbs. of copper sulphate is used in 50 gallons of water. The strength, recommended in the above formula, would be 6 lbs. for **48** gallons of water. What is the purpose ? Solignum is also a strong repellent. Paris green is a stomach poison and is normally used in the strength of 0·5 lb. in 50 gallons of water. The dose, recommended by the author ($1\frac{1}{2}$ lbs. in 48 gallons of water), is very strong. The object of these very strong repellents, which have to be sprayed every tenth day, is that the weevils should not approach the tree for egg laying. If the weevils do not come to the tree, what is the object of an extra dose of a stomach poson.

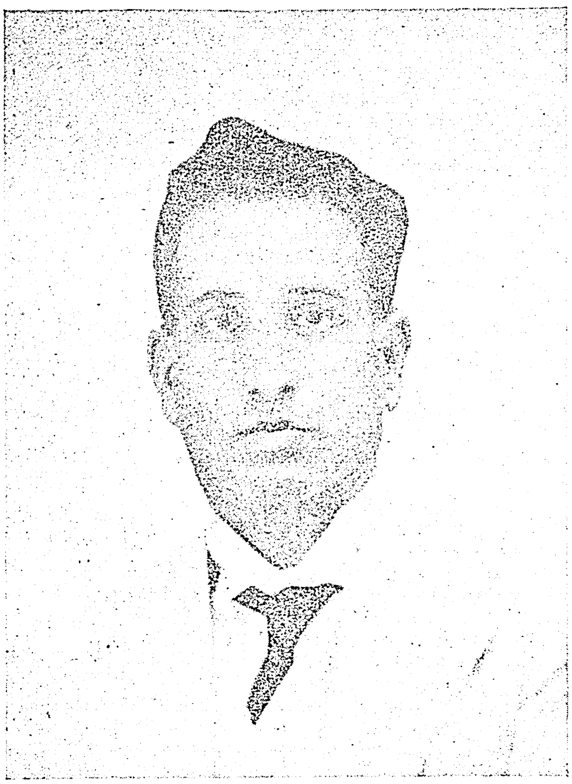
Sabour, *Bihar*. A. C. SEN.

NEWS AND ANNOUNCEMENTS

We regret to record the death of Mr. P. N. Krishna Ayyar (1894–1946), a Foundation Member of the Entomological Society of India.

The South India Branch of the Entomological Society of India, in its meeting held at Coimbatore on the 16th March 1946, passed the following resolution:—

"We, the members of the Entomological Society, are shocked at the sudden and sad demise of our collegue, Mr. P. N. Krishna Ayyar, and resolve to convey our heart-felt condolence to the members of the bereaved family."



MR. P. N. KRISHNA AYYAR

Mr. P. N. Krishna Ayyar was born in 1894 in village Pashambalakode in the Cochin State and belonged to an orthodox Brahmin family. He graduated from the Presidency College, Madras, in 1916, taking Zoology and Geology as his main and subsidiary subjects, respectively. From 1917 to 1920, he served as a Sub-Assistant in the Madras Fisheries Department and subsequently as an

Assistant Lecturer in Entomology till 1935 when he was appointed as Parasitologist, under a scheme of the Indian Central Cotton Committee, to investigate the possibilities of biological control of the cotton stem weevil, *Pempheres affinis* Fab. On the termination of this work, he was appointed Lecturer in Entomology in the Agricultural College, Coimbatore, in which capacity he served till his death.

Mr. P. N. Krishna Ayyar combined in himself the qualities of a capable lecturer with that of an ardent research worker. His early interests included field rats, eelworms and stored grain pests. Later, some of his papers dealt with ants. The last six years of his career are distinguished mainly by the publication of papers on the biology of *Pempheres cffinis* and its parasites. Altogether, Mr. Krishna Ayyar published 26 papers during a research career of about fifteen years (1929–1944). His death at a time when he had acquired a very ripe experience and sound judgement as an Entomologist, has undoubtedly closed a career of great usefulness to Indian Entomology. Mr. P. N. Krishna Ayyar was an extremely agreeable person, always refined and unruffled, and many, who came in contact with him, will long remember his attitude of devotion and reverence to scientific research and to life itself, even such as it is.

K. B. LAL.

PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF INDIA, 1946

Delhi Branch—New Delhi

General—

Dr. E. S. Narayanan and Mr. Rattan Lal were elected President and Secretary of the Branch Society, respectively.

5th April

Communications—

Some observations on the Sugarcane mite, *Paratetranychus indicus* Hirst. and its effective predator at Sakrand, Sind—M. Haroon Khan.

Some biological observations on *Empoasca Kerri*, Var. *motti*, Pruthi, with notes on the damage it causes to potato plants—Rattan Lal.

United Provinces Branch—Cawnpore

General—

Messrs. R. N. Singh, Shumsher Singh and M. A. Aziz were elected President, Vice-President and Secretary of the Branch Society, respectively.

5th January

Communications—

Sex ratio in *Dorysthenes hugelii* Redt., collected at light—Z. A. Siddiqi.

On *Trichogramma* spp. of India—K. B. Lal.

Factors influencing the development of eggs of the mango mealy bug, *Drosicha stebbingi* Green—R. N. Singh.

Exhibits—

Eupterotid caterpillars from *chil bil* (*Ulmus integrifolia*) tree with photographs of the infested tree—P. L. Chaturvedi.

13th April

Communications—

Moth-proofing tests and evaluation of treatment—S. P. Saxena.

Geographic changes as a cause of insect pest outbreaks—Shumsher Singh.

Exhibits—

Galls on the twig of *Phyllanthus emblica*, caused by a caterpillar—R. N. Singh.

Baluchistan Branch—Quetta

General—

Messrs. N. A. Janjua and Ghulam Ullah were elected President and Secretary of the Branch Society, respectively.

26th March

Exhibits—

Hyponomeuta padella (Linn.), a pest of apple in Ziarat Valley—Badrul Haq.

Hibernating larvae of *Euproctis signata* Blan., a pest of apple in Quetta—Zunnur Ahmad.

Mode of hibernation of codling moth larvæ—Chaman Lal Jolly.

Grasshoppers damaging wheat in Loralai district—Abdul Haq Qureshi.

Bombay Branch—Poona

General—

Dr. K. N. Trehan, Mr. P. M. Verma and Dr. E. J. Vevai were elected President, Secretary and Joint-Secretary of the Branch Society, respectively.

23rd March

Communications—

Future of Entomology in India—Khan A. Rahman.

115-47 Printed at The Bangalore Press, Bangalore Cty, by G. Srinivasa Rao, Superintendent.

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STUDIES ON *SCHISTOCERCA GREGARIA* (FORSKÅL)*

XIII. FOOD AND FEEDING HABITS OF THE DESERT LOCUST†

By M. AFZAL HUSAIN, M.A., I.A.S., *Lahore*,

C. B. MATHUR, M.SC., *Locust Warning Organization, New Delhi*,

and

M. L. ROONWAL, M.SC., PH.D. (CANTAB.), F.N.I., HONY. MAJOR,

Zoological Survey of India, Benares Cantt.

CONTENTS

I. INTRODUCTION

In the control of the desert locust, poison baiting is one of the measures of proved utility. Poison baiting, however, is not quite so simple a process as it may appear. Its efficacy depends on a number of factors, among the most important ones being the period of moulting and the physiological condition of the insect, which in its turn depends upon various environmental factors acting together. Therefore, a necessary prelude to a successful baiting campaign is

* These observations were made during the work done under the Locust Research Scheme financed by the Imperial Council of Agricultural Research, India.

† For earlier papers of this series see: *Indian J. agric. Sci.*, 1933, **3**: 639–45; 1936, **6**: 188–262, 263–67, 586–90, 591–623, 624–64, 665–71, and 1005–30; 1937, **7**: 317–25; 1940, **10**: 927–44; and *Indian J. Ent.*, 1943, **5**: 107–15, **7**: 89–101. (No. XII of this series was inadvertantly marked XIII, *Ind. J. Ent.*, **7**: 89–101.)

a thorough understanding of the feeding habits of the locust with special reference to the environment. Published information on the subject is scanty, but the importance of a knowledge of the conditions favourable for successful poison baiting is gradually being realized. We take this opportunity, therefore, of presenting some of our observations on the subject.

II. FOOD PREFERENCE

It is during the non-swarming periods that the desert locust may be said to live its 'normal' life, in its permanent or semi-permanent breeding grounds, swarming being regarded as only a transitory phase which lasts for a comparatively short duration. Even during the period of mass swarming some individuals may continue to live a non-swarming life in their normal breeding grounds. This means that while the non-swarming life is a continuous one for the species, the swarming life is but a temporary phase characterised by mass multiplications and mass movements and occurring at intervals, on account of some special factors both external and internal.

The permanent breeding grounds of the desert locust lie in sandy tracts. Therefore, the food of this locust in the *solitaria* phase consists of wild vegetation which is of little or no economic importance. With the advent of conditions favourable for rapid multiplication, huge swarms appear, which sooner or later infest cultivated fields. Their wide-spread ravages had, in the past, made people believe that the locust is capable of eating almost everything—from grass to human babies. This, however, is not quite correct. It has been shown (Husain and Mathur, 1936) that in order to obtain its supply of water the desert locust may go even to the extent of eating a mere roughage like wool, provided it is moist. Hoppers and fliers may eat their own kind. This, however, is exceptional, the locusts being essentially vegetarians.

Field observations and laboratory experiments show that although the desert locust is not fastidious in the choice of its food-plants, yet there are a few plants that it does not eat and there are others which it eats with great reluctance. The following is a brief account of the laboratory experiments done at Lyallpur during 1931 and subsequent years. Nearly 200 species of plants were experimented with.*

In most of the trials only hoppers of III, IV and V instars were employed. It was only in some cases that adults were tried in addition to the hopper stages. A number of hoppers, varying from four to six, were liberated in a small, rectangular, wire-gauze cage with a wooden floor. A fresh twig of the plant under trial was placed in the cage with the cut end of the branch dipping in water. In another similar cage, the same number of hoppers and of the same instars as in the experimental cage, were provided with a branch of cotton plant similarly placed. This served as control. After twenty-four hours the amount

* A useful list of the more common plants of the desert areas of North-Western India, with their scientific and local names, has been given by Rao (1941).

of leaf eaten was determined. The plants that were eaten with the same relish *i.e.*, in about the same quantity as the cotton leaf, which was considered as standard, were recorded as 'food-plants'. In those cases where only a little of the plant was eaten or the plant was left altogether untouched, the hoppers were subsequently caged on the plant itself, damaged leaves of the plant having been first removed to avoid mistakes. The plants were examined every day and observations were continued till the hoppers died of starvation. We give below three lists of plants which were tried, arranged under the following three categories:—

(i) 'Plants not eaten at all' (Table I).

(ii) 'Plants eaten with great reluctance', including plants that were nibbled occasionally but of which enough was not eaten for sustenance (Table II).

(iii) 'Food-plants', *viz.*, plants eaten freely (Table III).

Out of over 200 plants, belonging to some 60 different Natural Orders, it was found that less than a dozen plants were absolutely refused and about 30 were eaten with very great reluctance. Künckel d'Herculais (1893–1905) gave a comparatively extensive list of such plants which outnumber those which, according to him, were eaten by the desert locust. There are certain plants which he included both among palatable and unpalatable plants. His observations are 'comparative'. Plants that were not eaten in the presence of favoured plants were placed in the category of unpalatable plants. Mann and Burns (1927) gave lists of plants damaged and undamaged by desert locust swarms in Sind and Kathiawar during the years 1926–27. The following plants were reported as undamaged:—*Ixora parviflora*, *Tecoma stans*, *Mimusops elegi*, *Melia azadirachta*, *Nerium odorum*, *Croton* spp. and *Solanum nigrum*. Roonwal (1937–38) carried out some food-preference experiments in Mekran (S. Baluchistan).

The observations given above by us do not imply that amongst the favourite food-plants the locust makes no discrimination. When in a position to do so, it does exercise some sort of a choice. In a general way it may be said that the succulent and tender foliage is preferred to harder and older leaves. It was noticed in 1930 by one of us that a swarm alighting on a row of trees along a road in Moradabad district (U.P.) consumed almost every leaf of the mango (*Mangifera indica*) trees but left the neighbouring *Jaman* tree (*Eugenia jambolana*) practically untouched, although both are acceptable to the locust. Most of the adults that in the first instance alighted on the *Jaman* trees left them for the neighbouring mango trees in a sort of continuous stream.

A similar observation has been recorded by Telenga (1930) in Khorezm (U.S.S.R.). He states: "Of cultivated plants, cotton, sorghum, and lucern were attacked by the hoppers (of the desert locust) and cotton, lucern, eleguds and apricot by the adults. *Wheat was entirely avoided*". No mention has been made of the age of the wheat plants. Presumably they were in an advanced

TABLE I. *Plants not eaten at all*

Sl. No.	Botanical name	Natural Order	English name	Hindi or Punjabi name
1	*Crinum capense*	AMARYLLIDACEAE	..	..
2	*Allium cepa*	LILIACEAE	Onion	*Piaz*
3	*Malvastrum tricuspidatum*	MALVACEAE	..	..
4	*Melia azedarach*	MELIACEAE	Persian lilac	*Derek*
5	*Melia azadirachta*	MELIACEAE	..	*Neem*
6	**Calotropis gigantea*	ASCLEPIADACEAE	..	*Mudar, Ak*
7	*Canna indica* (green leaves)	CANNACEAE	Canna	*Akik*
8	*Canna sp.* (purple leaves)	CANNACEAE	,,	,,
9	*Woodfordia floribunda*	LYTHRACEAE		*Dhan, Dhanla*

* Leaves refused, but flowers were eaten. (See Table III.)

TABLE II. *Plants eaten with great reluctance*

Sl. No.	Botanical name	Natural Order	English name	Hindi or Punjabi name
1	*Agave americana*	AMARYLLIDACEAE	Railway-aloe	*Vilayati Kantala*
2	*Agave vivipera*	,,	Agave	..
3	*Cyperus flabelliformis*	CYPERACEAE	..	..
4	*Cynodon dactylon*	GRAMINEAE	..	*Khabbal*
5	*Bombax malabaricum*	BOMBACACEA	Silk-cotton tree	*Simbal*
6	*Hibiscus rosa-sinensis*	MALVACEAE	Shoe flower	*Jasum*
7	*Peganum harmala*	ZYGOPHYLLACEAE	..	*Harmal*
8	*Averrhoa carambola*	OXALIDACEAE	Carambola	*Khamrakh*
9	*Aegle marmelos*	RUTACEAE	Bael	*Bel*
10	*Albizzia procera*	LEGUMINOSAE	..	*Safed Siris*
11	*Dalbergia sisso*	,,	..	*Tali*
12	*Spiraea corymbosa*	ROSACEAE	..	..
13	*Dentzia staminea*	SAXIFRAGACEAE	..	..
14	*Lagerstroemia indica*	LYTHRACEAE	China crape	*Soani, Dhaura*
15	*Citrullus vulgaris*	CUCURBITACEAE	Water melon	*Mateera, Tarbuz*
16	*Jasminum grandiflorum*	OLEACEAE	Spanish jasmine	*Safed Chambeli*
17	*Jasminum arborescens*	,,	,,	..
18	*Vinca rosea*	APOCYNACEAE	..	..
19	*Cryptostegia grandiflora*	ASCLEPIADACEAE	Trop. African rubber	..
20	*Capsicum frutescens*	SOLANACEAE	Chillie	*Lal mirch*
21	*Datura stramonium*	,,	Thorn apple	*Dhathura*
22	*Hyoscyamus niger*	,,	Dondohorton	*Khurasani Ajwan*
23	*Thunbergia grandiflora*	ACANTHACEAE	..	..
24	*Justicia ventriosa*	,,	..	..
25	*Vitex negundo*	VERBINACEAE	..	*Wana, Marwan, Nirgandi*
26	*Aristolochia* sp.	ARISTOLOCHIACEAE	..	..
27	*Crozophora tinctoria*	EUPHORBIACEAE	..	..
28	*Putranjiva roxburghii*	,,	..	*Jiaputa, Patrjan*
29	*Buxus sempervirens*	BUXACEAE	Box tree	*Chikri, Shamshad, Papri*

TABLE III. *Plants on which locusts feed readily*

Sl. No.	Botanical name	Natural Order	English name	Hindi or Punjabi name
1	*Andropogon involutus*	GRAMINEAE	..	*Munji*
2	*Arundo donax*	,,	Spanish reed	*Nara*
3	*Bambusa arundinacea*	,,	Bamboo	*Bans*
4	*Dactyloclenium aegyptiacum*	,,	..	*Madhana*
5	*Pennisetum typhoides*	,,	Bulrush millet	*Bajra*
6	*Saccharum arundinaceum*	,,	..	*Munja*
7	*Saccharum officinarum*	,,	Sugarcane	*Ganna, Ookh*
8	*Saccharum sachaenanthus*	,,	..	..
9	*Saccharum sara*	,,	..	*Sarkanda*
10	*Saccharum spontaneum*	,,	Wild cane	*Kaighas*
11	*Sorghum vulgare*	,,	Great millet	*Jowar*
12	*Sorghum halepense*	,,	Johnson's grass	*Baru*
13	*Zea mays*	,,	Maize	*Makki*
14	*Arum colocacia*	PALMEA	Colcacia	*Arvi*
15	*Chaerops fortunei*	,,	..	*Patha*
16	*Smilax sagittaefolia*	LILIACEAE	..	..
17	*Agave rigida*	AMARYLLIDACEAE	..	..
18	*Musa sapientum*	MUSACEAE	Banana	*Kela*
19	*Alpinia nutans*	ZINGIBERACEAE	..	..
20	*Curcuma longa*	,,	Turmeric	*Haldi*
21	*Salix tetrasperma*	SALICACEAE	..	*Bedleila*
22	*Populus nigra*	,,	Lombardy poplar	*Safeda*
23	*Casuarina equisetifolia*	CASUARINACEAE	Serve	..
24	*Boehmeria nivea*	URTICACEAE	China grass	..
25	*Ficus bengalensis*	MORACEAE	Banyan	*Bar*
26	*Ficus religiosa*	,,	Pipal	*Pipal*
27	*Ficus glomerata*	,,	..	*Kathgular*
28	*Ficus elastica*	,,	Indian rubber plant	..
29	*Ficus infetaria*	,,	..	*Jangali pipali*
30	*Ficus palmata*	,,	..	*Phagwar*
31	*Ficus carica*	,,	Fig	*Anjeer*
32	*Ficus rumphii*	,,	,,	*Pikhan*
33	*Morus alba*	,,	Mulberry	*Shaitut*
34	*Morus laevigata*	,,	..	*Toot*
35	*Ulmus integrifolia*	,,	..	*Kain*
36	*Polygonum serrulatum*	POLYGONACEAE	..	*Kesru*
37	*Chenopodium album*	CHENOPODIACEAE	Pigweed	*Bathu*
38	*Kochia indica*	,,	..	*Kaurauro*
39	*Spinacia oleracea*	,,	Spinach	*Palak*
30	*Alternanthera discolor*	AMARANTACEAE	..	..
41	*Amaranthus caudatus*	,,	Love lies bleeding	*Kedari ohua*
42	*Amaranthus paniculatus*	,,	..	*Sil*
43	*Amaranthus* sp.	,,	..	? *Bathu*
44	*Digera arvensis*	,,	..	..
45	*Mirabilis jalapa*	NYCTAGINACEAE	..	*Gul abbas*
46	*Portulaca oleracea*	PORTULACACEAE	..	*Kulfa*
47	*Trianthema pentandra*	FICOIDEAE	..	*Itsit*
48	*Clematis paniciculatus*	RANUNCULACEAE	..	*Phul*
49	*Cleome brachecarpa*	CAPPARIDACEAE	..	*Krund*
40	*Brassica rapa*	CRUCIFERAE	Turnip	*Gunglu*
51	*Flacourtia sapida*	FLACOURTIACEAE	..	*Kukai*
52	*Benincasa hispida*	CUCURBITACEAE	White gourd	*Petha*
53	*Cucumis melo*	,,	Sweet melon	*Kharbuza*
54	*Cucumis sativus*	,,	Cucumber	*Khira*
55	*Cucumis utilissimus*	,,	..	*Tar*
56	*Lagenaria vulgaris*	,,	Bottle gourd	*Kaddu*
57	*Luffa aegypliaca*	,,	Loofah	*Ghiya Tori*
58	*Momordica charantia*	,,	Bitter gourd	*Karela*

TABLE III—(*Contd.*)

Sl. No.	Botanical name	Natural Order	English name	Hindi or Punjabi name
59	*Hypericum cernnum*	HYPERICACEAE	Bitter gourd	*Pinli*
60	*Gossypium hirsutum*	MALVACEAE	American cotton	*Kapas*
61	*Gossypium barbadense*	,,	Desi cotton	*Kapas*
62	*Hibiscus tiliaceus*	,,	..	*Jangli sankokra*
63	*Hibiscus mutabilis*	,,	..	*Jangli binda*
64	*Hibiscus esculentus*	,,	Lady's fingers	*Bhindi*
65	*Lavatera kashmiriana*	,,	..	*Gulkhaira*
66	*Grewia asiatica*	TILIACEAE	..	*Phalsa*
67	*Euphorbia thymifolia*	EUPHORBIACEAE	..	*Chota dudhi*
68	*Mallotus philippinensis*	,,	Monkey-face tree	*Rona*
69	*Ricinus communis*	,,	Castor	*Arand*
70	*Spaium sabiferum*	,,	..	..
71	*Linum usitatissimum*	LINACEAE	Linseed	*Alsi*
72	*Tribulus terrestris*	ZYGOPHYLLACEAE	Caltrops	*Bhakkra, Gokhru*
73	*Hiptaga madablota*	MALPIGHIACEAE	..	*Kamti*
74	*Citrus limetta*	RUTACEAE	Sweet lime	*Mitha*
75	*Citrus aurantium*	,,	Orange	*Santra*
76	*Feronia limonia*	,,	Wood apple	*Kathel*
77	*Boswellia serrata*	BURSERACEAE	Salar	*Salhi*
78	*Cedrela toona*	,,	..	*Tun*
79	*Odina wodier*	ANACARDIACEAE	..	*Jhingan*
80	*Pistacia integerrina*	,,	..	*Saravan*
81	*Magnifera indica*	,,	Mango	*Am*
82	*Dodonaea viscosa*	SAPINDACEAE	..	*Sanathu*
83	*Acer negundo*	,,	..	*Kukandra*
84	*Acer oblongum*	,,	..	*Mark*
85	*Gymnosporia spinosa*	CELASTRACEAE	..	*Suraghazai*
86	*Ziziphus jujuba*	RHAMNACEAE	..	*Ber*
87	*Eriibotrya japonica*	ROSACEAE	Loquat	*Loquat*
88	*Prunus padus*	,,	Bird cherry	*Jamoi*
89	*Prunus domestica*	,,	..	*Zurdalu*
90	*Prunus persica*	,,	Peach	*Aru*
91	*Pyrus malus*	,,	Apple	*Seo*
92	*Pyrus communis*	,,	Pear	*Nakh*
93	*Rubus biflorus*	,,	..	*Dher*
94	*Rubus caesius*	,,	..	*Karer*
95	*Rosa damascena*	,,	Rose	*Gulab*
96	*Acacia modesta*	LEGUMINOSAE	..	*Phulai*
97	*Acacia torota*	,,	..	*Mahu*
98	*Arachis hypogaea*	,,	Ground nut	*Mungphali*
99	*Bauhinea purpurea*	,,	..	*Koiral*
100	*Bauhinia vahlii*	,,	..	*Malghan*
101	*Cajanus indicus*	,,	Pigeon pea	*Arhar*
102	*Caesalpina bonducella*	,,	Nicker nuts	*Katkaranj*
103	*Cassia fistula*	,,	Indian laburnum	*Ambaltas*
104	*Ceratonia siliqua*	,,	Carob bean	*Kharnule*
105	*Cicer arietinum*	,,	Gram	*Chana*
106	*Glycyrrhiza triphylla*	,,	..	*Mulathi*
107	*Glycyrrhiza glandulifera*	,,	..	..
108	*Mimosa pudica*	,,	Sensitive plant	*Lajvanti*
109	*Pisum sativum*	,,	Field pea	*Matar*
110	*Pongamia glabra*	,,	Indian beach	*Papar*
111	*Vicia faba*	,,	Broad bean	*Bakla*
112	*Punica granatum*	PUNICACEAE	Pomegranate	*Anar*
113	*Quisqualis indica*	COMBRETACEAE	..	*Rangun-ki-bel*
114	*Terminalia tometosa*	,,	..	*Asaina*
115	*Eugenia jambos*	MYRTACEAE	Rose apple	*Jamun*
116	*Eucalyptus citriodora*	,,	Eucalyptus	? *Sufeda*

TABLE III—(*Concld.*)

Sl. No.	Botanical name	Natural Order	English name	Hindi or Punjabi name
117	*Psidium guajava*	MYRTACEAE	Guava	*Amrut*
118	*Mimusops kanki*	SAPOTACEAE	..	..
119	*Jasminum sambac*	OLEACEAE	Arabian jasmine	*Motia*
120	*Myctanthes arportristis*	,,	..	*Harsangar*
121	*Olea cuspidata*	,,	..	*Kahu*
122	*Salvadora sp.*	SALVADORACEAE	..	..
123	*Beaumontia grandiflora*	APOCYNACEAE	..	..
124	*Plumeria acutifolia*	,,	Frangipani tree	*Gulchin*
125	*Tabernaemontana heymena*	,,	..	..
126	*Wrightia coccinea*	,,	..	..
127	*Calotropis gigantia* (flowers)	ASCLEPIADACEAE	..	*Mudar, Ak*
128	*Cordia myxa*	BORAGINACEAE	Myxia	..
129	*Ehretia serrata*	,,	..	..
130	*Batatas edulis*	CONVOLVULACEAE	..	..
131	*Convolvulus arvensis*	,,	..	..
132	*Ipomoea pilosa*	,,	..	..
133	*Lantana camara*	VERBENACEAE	Lantana	..
134	*Lippia nodiflora*	,,	..	*Mokana*
135	*Callicarpa macrophylla*	,,	..	*Bauna*
136	*Tectona phlomoides*	,,	Teak	*Saigun*
137	*Tectona grandis*	,,	,,	,,
138	*Ocimum sanctum*	LABIATEAE	Sacred Basil	*Tulsi*
139	*Salvia plebeia*	,,	..	*Samunder sok*
140	*Datura stramonium**	SOLANACEAE	Thorn apple	*Dhathura*
141	*Lycopersicum esculentum*	,,	Tomato	*Tamatar*
142	*Nicotiana tabacum*	,,	Tobacco	*Tamakhu*
143	*Physalis peruviana*	,	Cape gooseberry	*Rasbhary*
144	*Solanum tuberosum*	,,	Potato	*Alu*
145	*Solanum melongena*	,,	Brinjal	*Baingan*
146	*Solanum xanthocarpum* (leaf, stem and fruit)	,,	..	*Katali*
147	*Bignonia venusta*	BIGNONIACAE	..	..
148	*Oroxylum indicum*	,,	..	*Mulin*
149	*Tecoma radicans*	,,	..	..
150	*Tecoma stans*	,,	..	..
151	*Rubia cordifolia*	RUBIACEAE	Indian mudder	*Manjit*
152	*Stephegyne parvifolia*	,,	..	*Kaem*
153	*Lonicera chinensis*	CAPRIFOLIACEAE	..	..
154	*Ageratum conyzoides*	COMPOSITEAE	..	..
155	*Carthamus oxyacantha*	,,	..	*Kantiari*
156	*Chrysanthemum indicum*	,,	..	..
157	*Cynara scolymus*	,,	Globe artichoke	..
158	*Lumnaea nudicaulis*	,,	..	*Batthal*
159	*Rhymcospermum jasminoides*	,,	..	..
160	*Taraxacum officinale*	,,	Dandelion	*Kanphul*

* Doubtful if readily eaten.

stage and had hardened up, and the locusts were attracted to the other, more tender food-plants available. We have seen hoppers in bands feeding on wheat plants when green, cutting down the half-ripe ears and even the stems of ripe plants. In the Langhovat District, in the Algerian Sahra, which was invaded by exceptionally large swarms in 1933, Arnault (1934) observed that, whereas dates, figs, grape-vines and *Ailanthus* were severely attacked, tamarisks and pines were scarcely touched.

In the first week of November 1934, one of us visited the Dera Ghazi Khan district of the Punjab. This is a tract of land in which the desert locust of the *solitaria* phase had been observed to breed during the previous year or two. The region is mostly sandy and uncultivated. The chief wild bushes found there are:—(i) 'Boh' (*Aerua javanica*), (ii) 'Lana' (*Salsola foetida*), (iii) 'Thumma' or 'Chag' (*Citrullus colocynthis*) and (iv) 'Ak' (*Calotropis* spp.). Of these the first three are among the food-plants of the locust (category iii above). A thorough search in a portion of this region (Tibbi Ramgarh) showed that all the hoppers of the desert locust as well as certain other Acrididae were restricted to *boh* bushes. Not a single hopper was found on other bushes. This again shows that the locust does exercise choice in the matter of food. In the case of adults, while most of them were found on *boh* bushes, or on the soil in the vicinity of these bushes, several of them were found on other bushes also. It seems likely that these adults had only casually alighted on those plants and possibly, even at this stage, they restricted their feeding to *boh* alone.

Ballard *et al* (1932) have also recorded observations on food preference by the desert locust. It was observed that "hoppers in the fifth instar which were moving in large masses towards El Arish stopped immediately they entered the fig plantation south-east of El-Arish and began feeding voraciously on the leaves of the fig trees, preferring it to any other plant".

Volkonsky (1937) and Roonwal (1938) have noted the avoidance of *ak* and *neem* by the desert locust in Algeria and India. More recently, Bhatia (1940) has recorded the food-plants of this locust in the Sind-Rajputana desert area. Their observations agree with ours in several respects, and like us, they found that the *ak* and *neem* were absolutely avoided by the locust. Haroon Khan (1946), however, reports that *ak* leaves are sometimes eaten in Sind. Chauvin

TABLE IV. *List of food-plants in the field-cage*

Sl. No.	Botanical name	English name	Hindi or Punjabi name
1	**Morus laevigata* Wall.	Mulberry	*Shehtut*
2	**Ficus sarica* Linn.	Fig	*Anjeer*
3	*Dalbergia sissoo* Roxb.	..	*Sheesham*
4	*Bombax malabaricum* De.	Silk-cotton tree	*Simbal*
5	**Vitis vinifera* Linn	Grape vine	*Angoor*
6	**Citrus medica* Linn.	Citrus	*Khatta*
7	**Zea mays* Linn.	Maize	*Makki*
8	*Ricinus communis* Linn.	Castor	*Arand*
9	*Sorghum helepense* Pers.	Baru Grass	*Baru ghas*
10	*Andropogon pertusus* Wild.	..	*Palwan ghas*
11	*Vinca rosea* Linn.	..	*Rataniot*
12	**Canavalia ensiformis* De.	Beans	*Sem*
13	*Euphorbia pilulifera* L.	..	*Dadak*
14	*Euphorbia granulata* Porsh.	..	*Dadak*
15	*Phyllanthus niruri* Linn.	..	*Sada huzur naini*

* Favoured food plant.

(1946*b*) has studied the active principle of *neem* which is responsible for its avoidance by locusts.

In this connection our observations on the desert locust in confinement will be of interest. In a field-cage measuring 40 ft. by 50 ft., and 7 ft. 10 in. high, plants and grasses of fifteen kinds (Table IV) were grown. Plants that were more commonly eaten are marked with an asterisk. Of the remaining ones, some were sparingly eaten, while the others were not eaten at all. The most interesting case is that of citrus against *sheesham* (*Dalbargia sisso*). In three different parts of this cage there were growing side by side plants of citrus and *sheesham*, and in all cases *sheesham* remained untouched and citrus was freely eaten, including, in several places, even the bark (Fig. 1). A normal citrus tree is very thickly foliated at the time of the year when this photograph was taken. Generally, the locust has no apathy for *sheesham*. We have seen locust swarms settling on *sheesham* trees and feeding on them fairly vigorously. The above is, therefore, a pure and simple case of preference for the comparatively succulent and 'flavoury' leaf of citrus as compared to the prapery leaf of *sheesham*.

FIG. 1. A citrus (left) and a *sheesham* (*Dalbargia sisso*) growing side by side in a field-cage in which a large number of hoppers and fliers were being reared. Most of the leaves, and at several places even the bark of the citrus tree, have been eaten away. *Dalbargia* stands unattacked.
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To add another instance of preference: A swarm of *Schistocerca gregaria* adults that alighted in the experimental fileds of the Imperial Agricultural Research Institute, at Pusa (Bihar), in 1928 showed partiality for linseed and abstained from feeding on gram plant.

It may be mentioned here that a plant which may be readily eaten at a particular time of the year may not receive the same attention at another. *Capparis aphylla* (*karir*) is a plant of common occurrence in the sandy breeding-areas of the desert locust in India. During summer, when this plant has fresh tender shoots, it is one of the chief food for the locust and even its bark is freely eaten. On the other hand, in late winter and early summer this plant has no young and tender branches and the bark of the older branches is rather hard and non-succulent. Field observations have shown that during this period the locust is rarely found on this plant. In a laboratory test during May this plant

TABLE V. *Amount of food eaten by hoppers during various stages at variable temperatures (Food: Fig leaves)*

Stage	Ref. No. of experiment	Weight of hopper on entering the stage (gms.)	Amount of food eaten during the stage (gms.)	Food eaten in relation to body weight (Times)	Period		Temperature (°C.)	
					From	To	Average max.	Average min.
I ..	H	0·038	0·135	3·60	13–8–1930	17–8–1930	35·5	31·6
I ..	F	0·032	0·235	7·40	16–8–1930	22–8–1930	35·5	32·2
I ..	E	0·026	0·223	8·58	16–8–1930	22–8–1930	35·5	32·2
I ..	B	0·038	0·415	10·15	16–8–1930	22–8–1930	35·5	32·2
Average		0·033	0·234	8·85				
II ..	F	0·075	0·585	7·80	22–8–1930	28–8–1930	33·0	31·6
II ..	C	0·073	0·328	4·46	11–8–1930	16–8–1930	36·1	31·6
II ..	G	0·081	0·540	6·66	25–9–1930	30–9–1930	31·6	28·6
II ..	J2	0·076	0·667	8·70	20–8–1930	25–8–1930	35·5	31·9
Average		0·081	0·544	6·73				
III ..	F	0·180	1·166	6·48	28–8–1930	4–9–1930	32·4	21·6
III ..	D	0·180	1·560	8·70	26–8–1930	30–8–1930	33·3	28·8
III ..	C	0·214	0·820	4·00	16–8–1930	20–8–1930	35·5	32·3
III ..	J2	0·117	1·880	10·60	25–8–1930	30–8–1930	33·3	28·6
Average		0·191	1·373	7·30				
IV ..	H2	0·425	2·815	6·62	27–8–1930	3–8–1930	28·5	28·0
IV ..	E2	0·340	2·520	7·56	2–9–1930	9–9–1930	31·5	28·2
IV ..	B2	0·627	3·273	5·20	10–9–1930	16–9–1930	32·4	30·8
IV ..	A	0·366	2·360	6·45	6–9–1930	11–9–1930	32·4	28·0
Average		0·429	2·484	6·398				
V ..	F	0·810	5·43	6·70	11–9–1930	19–9–1930	33·2	28·7
V ..	E2	0·737	5·67	6·70	9–9–1930	19–9–1930	33·0	30·2
V ..	D	0·885	7·10	8·02	8–9–1930	17–9–1930	30·0	28·0
V ..	G	1·510	13·51	8·95	28–8–1930	10–9–1930	32·4	28·0
Average		0·950	7·78	8·02				

was not eaten at all, and was in fact classified as 'unpalatable'. But in October when it was profusely branching at Lyallpur, the hoppers readily ate the softer growing tips as well as the succulent bark. Mann (1927) was surprised to see *karir* being eaten by the desert locust. He observed: "In the jungle, to my surprise, the plant on which the locust settled most abundantly was the leafless *Karir** (*Capris aphylla*). They were vigorously gnawing the outer layer of succulent material from the green stalks of this plant and as a result, a few days later, almost all the shoots of many of these turned yellow and died." He made these observations during September and October 1926, and during this part of the year *karir* is in full bloom.

III. Amount of Food Eaten during the Various Stages

A comparison of the weight of the hopper with the amount of food eaten during the different stages is interesting. On an average, during each of the stages (I–V), the hoppers eat about six to eight times their own weight of fresh leaf (Table V). Apart from individual variations, there will be variation depending on the food-plant under observation. In these experiments, therefore, only one kind of food, *viz.*, fig leaves, was used throughout. The actual amount eaten was determined under more or less natural conditions. The hoppers were reared in cages which could be put on the plant with the required number of leaves enclosed (Fig. 2). Thus an abundance of fresh supply of food was assured.

FIG. 2. Some cages hanging on a tree and enclosing its leaves to serve as food for the hoppers being reared in the cages.

* *Karir* has scale-like leaves.

The leaf area eaten was measured from day to day, and at the close of each instar the total area of leaf eaten was determined. The weight of the leaf was calculated on the basis of the average weight of a large number of representative pieces of known area punched out of a number of leaves. In Table V four observations of each stage are given, but the averages are based on a larger series.

IV. FOOD CONSUMPTION IN RELATION TO TEMPERATURE

To analyse the effect of temperature on the amount of food eaten, experiments were carried out at constant temperature of 25, 27, 30 and 37° C. Table VI gives the average amount of fresh leaf eaten in terms of leaf-area and leaf weight, as well as the calculated amount of food eaten per day for the different stages. The insects were caged on cotton plants grown in pots (Fig. 3) and kept in electric thermostats; the remaining procedure of the experiment was the same as in the experiment last mentioned.

TABLE VI. *Amount of food eaten per day at constant temperatures (Food: Cotton leaves)*

Stage	Temp. (°C.) at which reared	No. of days in the stage	Average amount taken during each stage		Average amount eaten per day during the stage	
			Area in sq. cm.	Weight in gm.	Area in sq. cm.	Weight in gm.
I	37	4	6·02	0·1565	1·50	0·039
	33	4	7·1	0·1846	1·77	0·046
	30	4	7·4	0·1924	1·85	0·048
	27	5	8·2	0·2132	1·64	0·043
	25	8	8·8	0·2288	1·1	0·029
II	37	4	11·6	0·3016	2·9	0·075
	33	3	15·1	0·3936	5·033	0·1305
	30	5	19·25	0·50	3·85	0·10
	27	5	17·2	0·4572	3·44	0·0914
	25	8	14·6	0·3796	1·925	0·0474
III	37	4	38·0	0·988	9·50	0·247
	33	3	50·9	1·323	16·96	0·441
	30	5	50·6	1·316	10·12	0·263
	27	6	58·5	1·521	9·75	0·253
	25	10	60·0	1·56	6·00	0·156
IV	37	4	57·03	1·488	14·25	0·372
	33	5	99·46	2·585	19·89	0·517
	30	6	110·53	2·874	16·75	0·479
	27	9	98·6	2·574	10·95	0·286
	25	..	..	..	..	..
V	37	10	270·0	7·02	27·00	0·702
	33	9	275·1	7·153	30·47	0·795
	30	11	298·0	7·748	27·09	0·704
	27	..	..	..	..	..
	25	..	..	..	..	..

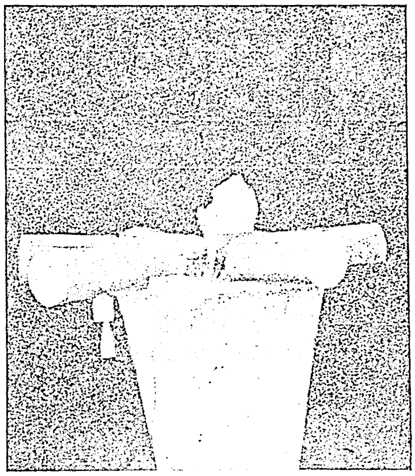

FIG. 3. Tubular cages fixed on leaves of a plant in a pot, and the whole placed in thermostat to rear hoppers at known constant temperature on fresh and constant supply of food.

A number of workers studying widely different insects, as for example, the cotton-boll-weevil (Hunter and Hinds, 1904 and 1905), lepidopterous larvae (Regener, 1865; Mitchener, 1928), larvae of aquatic beetles (Blunk, 1923), locusts (Nenjukov and Parfentjev, 1928) and Coccinellid beetles (Johnsen, 1930), arrived at the conclusion that the amount of food eaten by an insect increases with the rise of temperature. But, in the case of the desert locust we find that the relation of temperature and food consumption is not so simple. In this insect, generally speaking, the food consumption per day certainly bears a direct relation to temperature, but when the whole life of the insect or the duration of any particular stage is taken into consideration, the rule is that the amount of food eaten varies inversely with the change in temperature. Such results have been reported in the case of clothes moth (Titschack, 1925), and green-house leaf-tyre, *Phlyctaenia ferrugalis* (Filinger, 1931). Parker (1929 and 1930), on the other hand, found that the total amount of food taken by grasshoppers larvae remained practically the same at constant temperatures of 22° to 37° C. He explains this feature by saying that the increase in the daily amount of food eaten at higher temperature is counterbalanced by the shorter period of larval development. In the case of desert locust the results are different.

Going into the details of temperature effect, we find that the daily food consumption increases with the temperature upto 33° C., but beyond that there is no increase. In fact at 37° C. this figure is even lower than that at 33° C.

In this connection a glance at the effect of temperatures higher than 33° C. on the duration of hopper instars is of interest (Table VII). It is seen that the hastening effect of rise in temperature on the growth of the insect, resulting in the shortening of the larval duration, reaches its climax at 36° C., where the larval duration is the shortest. Similarly, the amount of food eaten per day (Table VI)

TABLE VII. *Duration of hopper instars at constant temperatures*

Temp. °C.	Duration of larval instars I to V (hours)					Total larval life (hours)	No. of observations
	I	II	III	IV	V		
30	100·5	81·9	91·7	114·1	203	591	11
36	76·1	68·8	87	82·0	174	488	8
37	70·0	69·8	84·6	87·6	182	494	10
39	67·0	72·0	88·5	88·5	192	502	3
40	67·5	71·1	79·4	79·4	147·7	496	11

reaches its climax somewhere between 33° and 37° C. At 37° C. there is a fall in the daily food consumption. The duration of the hopper stage does not shorten with rise of temperature beyond 36° C. On the other hand, one observes a definite prolongation of the hopper stages. Temperatures of 36° C. and above are known to be injurious for the desert locust, and this explains the lower food consumption accompanied by deterioration in the growth rate of the hoppers at these high temperatures.

V. PROPORTION OF FOOD UTILIZED BY THE HOPPERS

A rough estimate as to what proportion of the food eaten by the desert locust during its different hopper stages is utilized, was made. The technique of this experiment was briefly as follows:—

The experiment was started with freshly hatched hoppers and was continued till they reached the winged stage. The insects were singly caged on twigs of a fig tree. The area of the leaves enclosed was traced on paper. Each morning at 8·0 hours the area of the leaves eaten was marked out on the tracings of the respective leaves, and pieces of known area corresponding to portions eaten up by the hopper, were punched out, dried in an air oven at 100° C. and weighed. From these figures the average dry weight of one square centimetre of fig leaf was calculated. At the end of each hopper stage the area of leaf eaten up was measured from the tracings with a planimeter, and on the basis of the dry weight per square centimetre of fig leaf, as determined above, the dry weight of the leaf area eaten during the stage was calculated.

Every morning the fæcal matter passed out by the hopper during the previous twenty-four hours was collected. For this purpose we used a specially designed cage (Fig. 4). Its chief feature is the funnel-shaped bottom. A collecting tube was fixed below the stem of the funnel. All the fæcal matter collected into this tube and could be removed without disturbing the hopper. The faecal matter was dried and weighed for each stage of hopper separately. The difference between the dry weight of leaf eaten and the dry weight of faecal matter passed out gives the amount of food (minus water) utilized by the hopper. It appears that a major portion of the food eaten is thrown out as fæces. A greater percentage of food is assimilated by the desert locust in earlier hopper

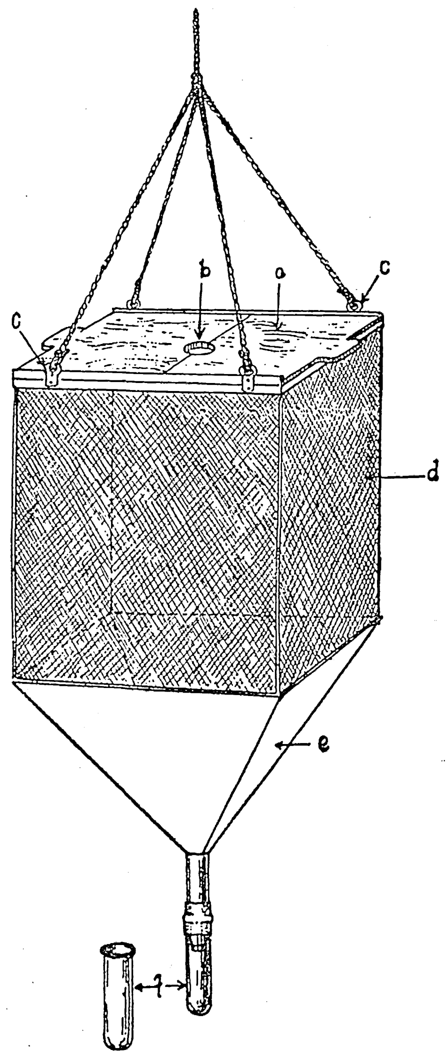

FIG. 4. A diagrammatic sketch of a cage having a conical base with a collecting tube attached to it.

(*a*) Sliding lid of the cage; (*b*) slit for twig; (*c*) hook and string for fixing the cage on to the plant; (*d*) wire-gauze sides; (*e*) metallic conical bottom; (*f*) collecting tube.

stages than in the later ones. The efficiency of the locust in this respect gradually falls from 48·5 per cent. in the first stage to 31·3 per cent. in the fifth stage. (*Vide* also Chauvin, 1946 *a*.) In Table VIII some representative observations of each stage are given, the averages being based on a larger number of observations.

TABLE VIII. *Dry matter of the food (fig leaves) utilized by the hoppers during various stages*

(The averages are based on a larger number of observations than those given here)

Stage	Ref. No. of experiment	(a) Wt. of leaf eaten (dry) gm.	(b) Wt. of faecal matter (dry) gm.	(a − b) Wt. of food assimilated by the system (dry gm.	Percentage of food (dry) assimilated by the system
I	F	0·054	0·018	0·036	48·5
	E	0·055	0·025	0·035	
	B	0·104	0·073	0·030	
Average		0·070	0·038	0·034	
II	F	0·138	0·120	0·018	42·2
	C	0·107	0·050	0·057	
	G	0·137	0·048	0·089	
	J	0·127	0·045	0·082	
Average		0·135	0·078	0·057	
III	H2	0·278	0·205	0·073	44·7
	C	0·207	0·130	0·077	
Average		0·242	0·167	0·025	
IV	E2	0·638	0·275	0·363	38·36
	C	0·625	0·450	0·175	
	G	1·020	0·625	0·395	
Average		0·696	0·469	0·267	
V	A2	1·350	1·045	0·305	31·30
	E2	1·435	0·820	0·615	
	B2	1·843	1·000	0·843	
Average		1·99	1·369	0·622	

VI. FASTING AND MOULTING

Insects about to moult, as a rule, stop feeding; they also fast for sometime after moulting. In the case of the desert locust this period is rather long and needs particular attention as it interferes with the efficiency of poison baiting. Baiting during these periods is of no avail because, by the time the hoppers resume their feeding activity the bait will have become too dry to be attractive to the locust. In Table IX a few representative cases of fasting before and after moulting in the hopper stages are given. During these observations the daily temperature range was 28–35° C.

Fasting before moulting is a physiological need for the insect. The fore- and hind-intestines, being ectodermal invaginations, are lined with cuticle which, along with the cuticle elsewhere, is cast off at each moult. It would assist ecdysis if these portions of the alimentary canal are free of their solid contents, which may hamper the process; this condition is achieved by fasting. A number of

TABLE IX. *Fasting period before and after moulting*

Stage	Ref. No. of experiment	Period of fasting before moulting (hours)	Period of fasting after moulting (hours)
I	4/A	18	11
	6/A	26	8
	8/A	26·5	6
	9/A	15	3
	10/A	19	9
Average ..		21	7
II	1	17	5
	4	18	11
	10	28	10
Average ..		20	8
III	2/A	21	17
	3/A	18	19
	7/A	29	15
	2/B	23	5
	5/B	22	8
	7/B	12	7
Average ..		20	12
IV	11	22	5
	15	24	9
	16	35	5
	1/iii	24	14
Average ..		26	8
V	1	27	39
	2	42	23
	6	38	21
	10	24	10
Average ..		33	20

dissections of insects immediately after moulting and before any food was taken were made. It was found that the fore-intestine was almost completely free of solid food-matter, but the mid-intestine was invariably gorged with food matter.

However, it is noteworthy that the time normally taken by the food to traverse the alimentary canal is much less than the fasting period preceding the moult (Tables IX and X).

VII. Time taken by the Food to Traverse the Alimentary Canal

The time taken by food to traverse the alimentary canal was determined by a physical and a chemical method. The proedure adopted in the latter case was as follows:

Cotton leaves moistened with gelatine water and thinly dusted with bismuth sub-nitrate powder were offered to the hoppers. The time at which they started eating such leaves and the time at which they finished the feed were noted. The bismuth-dusted leaves were then removed and replaced by plain cotton leaves. Hereafter the time of the discharge of every fæcal pellet was noted and the pellets qualitatively tested for bismuth. This was continued till one or two pellets containing no bismuth were obtained. On the basis of these data, representative cases of which for the various hopper stages are given in Table X, the time taken by the bismuth salt to traverse through the alimentary canal was calculated. This period may be taken to represent the time that is ordinarily taken by the food to pass through the alimentary tract of the locust. Bismuth sub-nitrate is a salt that is known to pass through the alimentary system of vertebrates without absorption or undergoing any chemical change. Chemical tests have shown this to be case with regard to the desert locust also. (*Vide* also Chauvin, 1946 *a*).

TABLE X. *Time taken by food to traverse the alimentary canal of the desert locust*

Sl. No.	Hopper stage	Temperature (degree C.)		Leaf dusted with bismuth sub-nitrate eaten at (hour of the day)	Normal leaf eaten after bismuth feed at (hour of the day)	Faecal pellet containing bismuth sub-nitrate discharged at (hour of the day)		Time taken by the bismuth salt to traverse through the alimentary canal			
								Minimum		Maximum	
		Max.	Min.			First pellet	Last pellet	Hrs.	Min.	Hrs.	Min.
1	I	23·0	18·0	7-53	10-35	10-05	12-50	2	12	4	54
2	I	25·5	25·5	10-45	11-13	11-15	14-10	0	30	3	22
3	I	,,	,,	11-55	12-10	13-07	14-20	1	12	2	22
4	II	,,	,,	10-55	12-43	11-32	14-23	0	37	3	25
5	II	,,	,,	10-24	11-53	10-33	14-10	0	9	3	44
6	III	27·7	24·4	12-06	12-13	12-54	15-33	0	48	3	23
7	III	,,	,,	12-00	12-16	13-14	16-22	1	14	4	19
8	IV	25·0	21·5	10-27	12-31	10-51	15-17	0	24	4	47
9	IV	,,	,,	10-39	12-27	12-41	14-35	2	2	3	35
10	IV	38·0	34·0	9-50	10-59	10-21	13-33	0	31	3	36
11	IV	,,	,,	11-06	13-20	12-27	14-54	1	21	3	41
12	V	36·0	34·5	9-20	10-15	11-13	15-15	1	53	6	50
13	V	,,	,,	9-20	10-05	11-13	15-02	1	53	5	37
14	V	25·0	22·0	10-07	14-34	12-13	17-50	2	6	7	32
15	V	,,	,,	10-33	14-10	11-39	18-33	1	6	7	49

These results were confirmed by the physical method in which the indicator used was blotting paper. Hoppers were kept singly in cages in which, instead of vegetable food, pieces of blotting paper soaked in water were provided. Hoppers that ate some blotting paper were thereafter provided with green leaf for eating. The time of eating the paper and that of the discharge of the first and the last faecal pellet containing fibres of blotting paper were noted. The duration gives the time which the blotting paper took in passing through the alimentary canal, and substantially approximates the figures obtained by the bismuth method.

TABLE XI. *Duration of the various larval stages in relation to food*

Stage and experiment No.	Fed on young cotton plant						Fed on old maize plant					
	L182/1	L182/2	L182/3	L182/4	L182/5	L182/6	L182/7	L182/8	L182/9	L182/10	L182/11	L182/12*
I	13 to 17-7-1933 (4 days)	13 to 17-7-1933 (4 days)	13 to 17-7-1933 (4 days)	13 to 17-7-1933 (4 days)	13 to 17-7-1933 (4 days)	13 to 18-7-1933 (5 days)	13 to 26-7-1933 (13 days)	13 to 22-7-1933 (Died in I stage) 9 days	13 to 18-7-1933 (5 days)	13 to 18-7-1933 (5 days)	13 to 19-7-1933 (6 days)	13 to 18-7-1933 (5 days)
II	17 to 23-7-1933 (6 days)	17 to 21-7-1933 (4 days)	17 to 22-7-1933 (5 days)	17 to 20-7-1933 (3 days)	17 to 21-7-1933 (4 days)	18 to 21-7-1933 (3 days)	..	..	18 to 25-7-1933 (7 days)	18 to 26-7-1933 (8 days)	18 to 27-7-1933 (8 days)	18 to 25-7-1933 (7 days)
III	Died on 23-7-1933 during moult	21 to 26-7-1933 and 26-7-1933 to 1-8-1933 (Extra moult)	22 to 26-7-1933 (4 days)	20 to 24-7-1933 (4 days)	21 to 25-7-1933 (4 days)	21 to 26-7-1933 (5 days)	..	..	..	26-7-1933 to 15-8-1933 Died during moulting (20 days)	27-7-1933 to 6-8-1933 (10 days)	25-7-1933 to 11-8-1933 (17 days)
IV	..	1 to 5-8-1933 (4 days)	26-7-1933 to 2-8-1933 (6 days)	24 to 29-7-1933 (5 days)	25 to 30-7-1933 (4 days)	26-7-1933 to 1-8-1933 (6 days)	..	..	..	..	6 to 13-8-1933 Died in V stage (7 days)	11 to 17-8-1933* (6 days)
V	..	..	2 to 8-8-1933 (6 days)	29-7-1933 to 7-8-1933 (9 days)	30-7-1933 to 8-8-1933 (9 days)	1 to 11-8-1933 (10 days)	..	..	..	..	..	17 to 22-8-1933* (5 days)

* Hopper L 182/12 was fed on leaves of maize plant during I, II and III stages and on cotton leaves during IV and V stages.

VIII. EFFECT OF QUALITY OF FOOD ON LARVAL DURATION

The desert locust is certainly polyphagous and, as already shown, the range of diet is very extensive. All the same, there are certain plants which have better nutritive value than others. In a series of experiments the hoppers were fed on young cotton and old maize plants, and the duration of the various stages was determined. The maize plants were sown in earthern pots, while the cotton plants were transplanted into pots from the field and were kept in the rearing room during the experiment. The cotton plants employed were young and were 8–12 inches high; the maize plants, on the other hand, were fairly old and measured 3–4 feet in height. The apical portion of maize plants carrying the more tender leaves was cut off and the basal part of the plant measuring about one foot was kept for feeding. The plants were enclosed in cylindrical wire-gauze cages 18 inches high and 9 inches in diameter. On each plant a single hopper of the first stage, selected from the same hatching, was liberated and a record of the moulting time of these hoppers was maintained (Table XI).

It will be seen that while the hoppers that were reared on cotton completed their development in 25–29 days, those on maize only passed through the first three stages during this period. It should be emphasized that the prolongation of the larval stages on maize was not on account of any pathological condition created by the food. This is evident from the case of hopper L 182/12. This hopper during I, II and III stages was fed on old maize leaves and showed marked prolongation in the duration of these stages. In its IV and V stages it was fed on cotton leaves with the results that the hopper took about the same time for these stages as any of the other hoppers reared on cotton plant from the very beginning. Telegna (1930) recorded that "the hopper stage of the locust bred on lucerne occupied 37 days as against 28–30 days in the case of those bred on cotton or Sorghum. Some hoppers fed on lucerne produced adults after only 4 months". This is confirmed by our observation that the quality of food does influence the rate of development. Extension of these observations, especially in reference to the phase *solitaria*, should be of considerable interest. The observations of Chauvin (1939) are also of interest in this connection.

IX. CANNIBALISM

Hoppers of the desert locust have often been observed to eat their own cast skins, a habit which, from the point of view of nourishment, is of doubtful value. This habit is not universal; the majority of the hoppers do not eat their exuviae. Only fresh exuviae are eaten. Possibly, they are eaten for the sake of the moisture of the moulting fluid that they carry.

More interesting is the habit of eating the living, and the dead and dying individuals of their own kind. We have observed a complete hatching consisting of more than 50 hoppers being devoured by about half a dozen of their brothers that had turned into cannibals. Of course, it is only the weaklings and the sickly and those in the inactive state (moulting) that fall an easy prey and are eaten.

Hoppers and adults with cannibalistic habits have been seen to make persistent attacks on others of their own species. In one case a fifth stage hopper was observed to persistently attack an adult female that was being reared in the same cage, for about three-quarters of an hour. In the end, the female, which was heavy with eggs had a portion of the base of its tegmen and a small portion of the neighbouring region of the thorax nibbled off by the aggressive hopper. Freshly dead locusts are also eaten, and the hoppers are regarded to serve as a good attractant and carrier in poison baits. Ballard and others (1932) have observed that bodies of poisoned dead hoppers and also those of burnt hoppers and adults "provided very attractive food for others". Our observations during locust control operations, particularly with regard to the advanced hopper stages, fully bear out this statement.

Faure (1932) has recorded an observation where some of the locust hoppers after hatching perched themselves at the opening of the bore of the mother egg-pod and greadily feasted on the soft and helpless hoppers that emerged after them.

In one experiment Duarte (1938) cut off both the hind-tibia at the femuro-tibial joint of three hundred hoppers of *Locusta migratoria migratorioides* and crowded them together. He observed that cannibalism on a large scale was going on, chiefly in the last two or three instars. These observations show that cannibalism is as a rule practised by hoppers on their disabled fellows.

Uvarov (1931) has suggested that a hopper takes to cannibalism when there is shortage of water. This is largely true, but there are exceptions. Certain hoppers prefer dead and dying hoppers even to fresh, green, succulent leaves which constitute the normal food of the insect.

Smee (1936) correlates cannibalism with over-crowding. Regarding the red locust of Africa, *Nomadacris septamfaciata* (Serv.), he observes: "In an area that has been closely laid over, this brings a number of newly hatched ones into contact with vermiform larvae and hoppers emerging from the egg-packets which they promptly attack and devour. It was only at this stage that hoppers were seen to destroy other living hoppers, but it was observed in all cases where concentrated egg-laying had taken place". In the case of the desert locust the cannibalistic habit gets more pronounced with the advance in the hopper stages.

Our observations on *Schistocerca gregaria* indicate that cannibalism originates from dearth of food material, and incidentally of water, the latter being obtained from food alone at a particular physiological state of the hopper which occurs at the end of the fasting period after ecdysis. Thus, the act of cannibalism is regarded, in the first place, only as an emergency measure to overcome food shortage, which, thereafter, may become not only a habit but also even a craving.

X. Summary

Nearly 200 species of common plants found at Lyallpur (Punjab) were tested as food for the desert locust. They have been classified in three categories:

(*a*) plants not eaten at all, (*b*) plants eaten with great reluctance, and (*c*) 'food-plants'. Only a few plants were totally refused. The desert locust exercises a well-defined choice of food when in a position to do so. As a rule, it prefers a succulent leaf to a papery one.

The hoppers of the desert locust eat almost 6–8 times their own mean weight of the stage.

The food consumption per day increases with rise in temperature (within certain limits). On the other hand, for the *total* life period the food consumption decreases as the temperature rises.

About 50 per cent. of the dry matter of the food (fig leaf) is absorbed by a first stage hopper during digestion. This proportion decreases as the hopper advances in age till a fifth stage hopper absorbs only about 30 per cent.

Hoppers before and after moult undertake a fast, but the period of fasting varies considerably with the individuals. Fasting before moulting lasts from 15–38 hours. The fasting period after the moult is shorter, ranging between 3–20 hours.

Food takes half an hour to two hours to traverse the alimentary canal of a hopper, and for complete evacuation of the food taken at one meal the time required varies from two and a half hours to seven hours.

The quality of food effects the duration of the hopper stages. Cannibalism is a fairly common feature under crowded conditions.

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NOTES ON THE STRUCTURE AND DEVELOPMENT OF THE FEMALE GENITAL ORGANS OF *CARPOPHILUS* SP. (NITIDULIDAE, COLEOPTERA), WITH A COMPARISON OF THE GENITAL ORGANS IN THE TWO SEXES

By R. RAKSHPAL, PH.D.
Lecturer in Entomology, The University, Lucknow

CONTENTS

I. INTRODUCTION

Although the development of the male reproductive organs in Coleoptera has been studied by a number of workers, the development of the female organs has not received adequate attention. Singh-Pruthi (1924), Heberdey (1931) and Metcalfe (1932) are the only workers who have studied the development of this system in female Coleopterous insects.

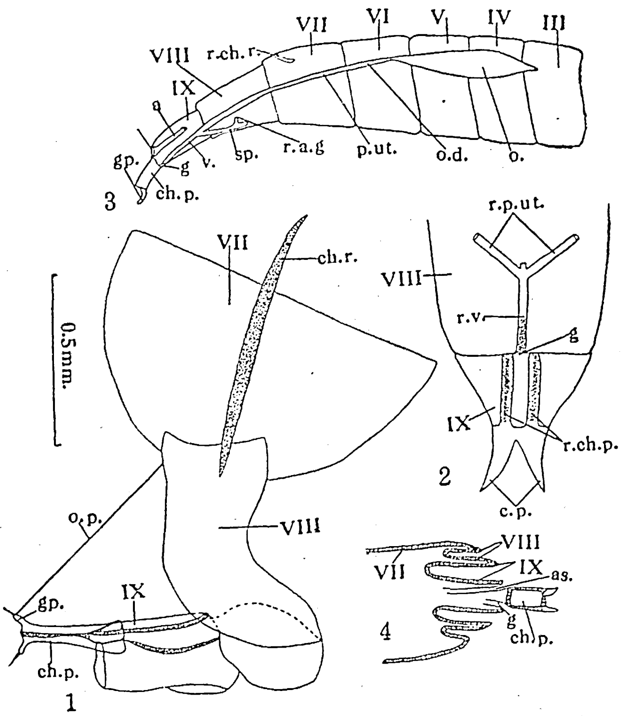
In most of the insect orders, the female genitalia are fully developed and are formed from the appendages of the eighth and ninth abdominal segments. But in the order Coleoptera the genitalia are completely suppressed in some families, while in others, they are reduced and represent only some of the appendages of these two segments. It is, therefore, interesting to study the development of the genitalia in those cases in which they are present in a reduced form and to know their exact homology. As the author has already studied the development of the male genital organs of the beetle *Carpophilus*, the author now gives an account of the development of the female reproductive organs of this beetle and has finally made a comparison of the development in the two sexes.

II. STRUCTURE OF THE FEMALE GENITAL ORGANS OF THE ADULT

The genitalia.—Of the nine abdominal segments, the first six are typical body segments, the seventh (Fig. 1, VII) is very much enlarged, while the eighth and ninth are modified to form the major part of the tubular retractile ovipositor. The ovipositor, therefore, seems to originate from the posterior end of the large seventh segment. Normally the ovipositor remains retracted within the seventh segment, and thus the abdomen appears to consist only of seven segments.

The ovipositor (Fig. 1, *o.p.*) consists of the following parts:—(1) the eighth abdominal segment (VIII) which is very much elongated and forms a more or less

membranous structure; in fact, it looks like a thin-walled chitinous cylinder; (2) the ninth abdominal segment (IX), which is about half the size of the eighth segment and also forms an elongated cylinder with thin chitinous walls which present a pair of longitudinal thickenings along their lateral walls; and (3) the genitalia, which consist of a chitinous pouch (*ch.p.*), a pair of genital palps (*gp.*), and a chitinous rod (*ch.r.*). The *chitinous pouch* is a tubular structure closed at



FIGS. 1–4. Fig. 1. Posterior part of the abdomen of the adult. Fig. 2. Diagrammatic ventral view of the last two abdominal segments of the last larval instar, showing the origin of the chitinous pouch, vagina and paired uteri. Fig. 3. Diagrammatic, side view of the posterior end of the pupa. Fig. 4. Diagrammatic side view of the last three segments of the late pupa, showing the telescoping of the viii and ix segments into the vii. *a*, alimentary canal; *as.*, anus; *ch.p.*, chitinous pouch; *ch.r.*, chitinous rod; *c.p.*, caudal processes; *g.*, gonopore; *gp.*, genital palps; *o.*, ovary; *o.d.*, oviduct; *o.p.*, ovipositor; *p.ut.*, paired uteri; *r.a.g.*, rudiments of accessory gland; *r.ch.p.*, rudiments of chitinous pouch; *r.ch.r.*, rudiments of chitinous rod; *r.p.ut.*, rudiments of paired uteri; *r.v.*, rudiments of vagina; *sp.*, spermatheca; iii-x segment numbers.

one end, with comparatively thick walls. Within this pouch lies a pair of chitinous thickenings, which are hinged on to the chitinous thickenings of the ninth segments. At its posterior end the pouch possesses a pair of palps (*gp.*), the genital palps, each bearing a small spine. The *chitinous rod* (*ch.r.*) is an elongated structure pointed at both ends and lying in the sixth and seventh abdominal segments. The

anal opening is situated at its posterior end dorsally to the chitinous pouch, while the gonopore is situated ventrally to the chitinous pouch.

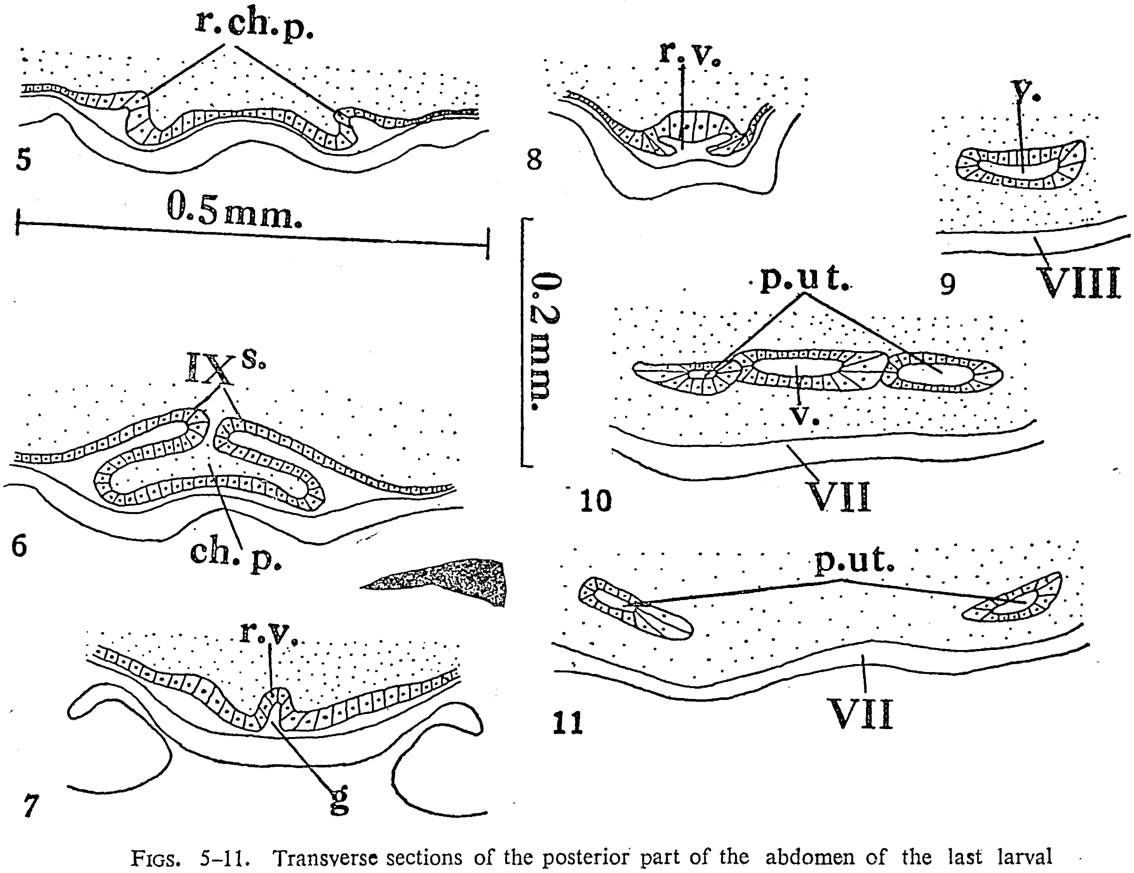
The internal genital organs.—The internal genital organs consist of the following parts:—(1) a pair of *ovaries* lying in the fifth and sixth segments; each ovary consisting of four ovarioles, all of which are packed together within a thin membrane; (2) a pair of *oviducts*, each of which is very slender and originates from the posterior end of each ovary, and opens into the uterus of its own side; (3) the *paired uteri*, which are short and thin-walled and are placed more or less transversely within the seventh abdominal segment; (4) the *vagina* into which the two uteri open together is very long and continues upto the posterior end of the ninth segment where the gonopore is situated; (5) the *accessory gland*, which is more or less club-shaped structure opening at the anterior end of the vagina; and (6) the *spermatheca*, which is a small chitinous tube opening into the vagina along with the accessory gland.

III. Development of the Female Genital Organs

The genitalia.—In the larva, nine distinct abdominal segments are present. The anus lies on a thin chitinous membrane on the ventral surface of the ninth sternum. The ninth segment (Fig. 2, IX) is comparatively smaller than the eighth (VIII) and bears a pair of lateral processes (*c.p.*) at its posterior extremity, which, however, degenerate soon and do not take any part in the formation of the genital appendages. In the early larval stages and right upto the early stages of the last larval instar no genital appendages are developed. When the last larval instar is fully developed a pair of groove-like inpushings (Fig. 5, *r.ch.p.*) are formed in the ninth sternum, which (Fig. 2, *r.ch.p.*) extend right upto its anterior margin, although they are less prominent anteriorly. This pair of inpushings are the first rudiments of the genital appendages. A median longitudinal groove (Fig. 7, *r.v.*) is formed at the same time in the eighth segment (Fig. 2, *r.v.*). This groove is the rudiment of the vagina.

As the larva pupates, the pair of inpushings on the ninth segment grow towards the middle line and meet there, and thus a pouch is formed which (Fig. 6) is the rudiment of the chitinous pouch. Later on a pair of buds, one on each side, grows laterally at the posterior end of the chitinous pouch. These buds are very small and form the rudiments of the genital palps. As the pupa develops further, the body-wall begins to chitinise, but the chitinisation does not extend over the eighth and ninth segments which remain membranous and flexible. The chitinous pouch (Fig. 3, *ch.p*,) shifts backwards and now comes to lie behind the ninth segment (IX). The genital palps (*gp.*) have also developed further. The chitinous rod (*r.ch.r.*) begins to develop (Figs. 22 and 23) as a thickening of the tergum of the seventh segment (VII) in the middle line; it grows anteriorly and then separates from the tergum to assume the shape of the adult structure.

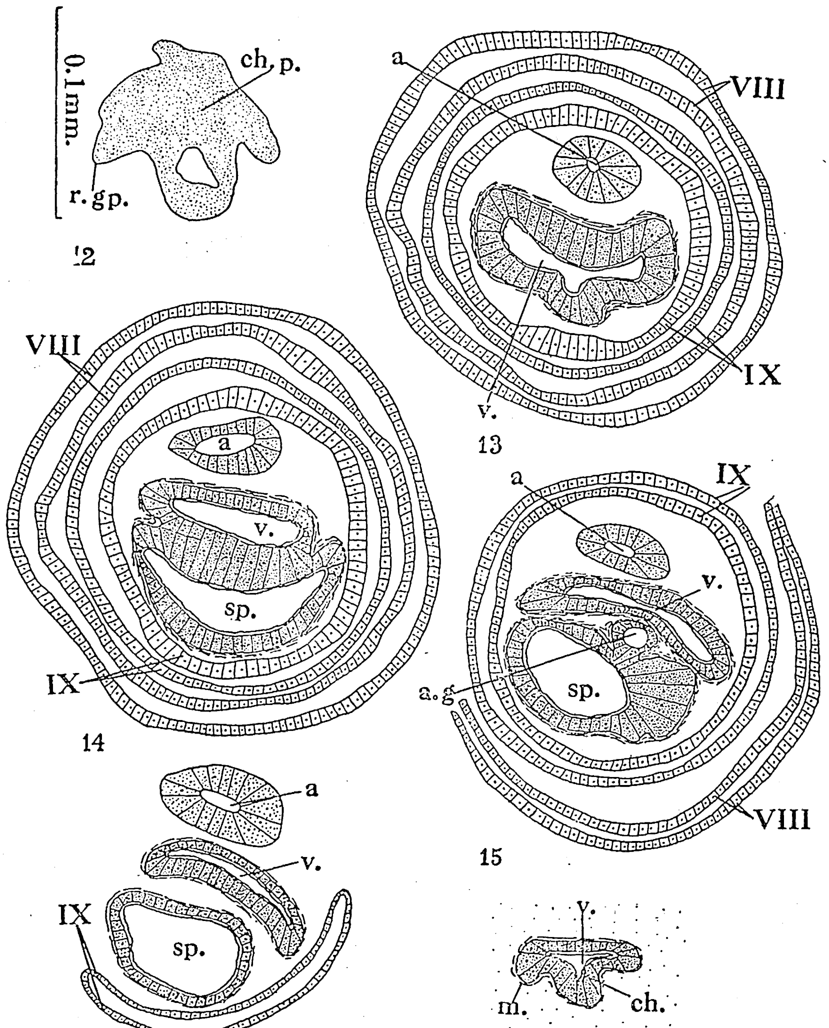
When the pupa is fully developed the ovipositor assumes more or less the same shape as that of the adult. The posterior segments (Figs. 4 and 13–16) become telescoped and thus four definite rings, one inside the other, are seen in transverse sections passing through this region; but the chitinous pouch always remains projecting behind the ninth segment (Fig. 4). The pouch develops a pair of thickenings, which grow anteriorly into the ninth segment. The genital palps (Fig. 12, *gp.*) develop further into their adult condition and become more or less club-shaped. The chitinous rod becomes elongated, and also assumes the adult structure.



FIGS. 5–11. Transverse sections of the posterior part of the abdomen of the last larval instar, from posterior to anterior. Fig. 5. Showing the origin of the chitinous pouch. Fig. 6. Formation of the chitinous pouch. Fig. 7. Origin of the vagina. Fig. 8. Vagina has not yet fully formed. Fig. 9. Fully formed vagina. Fig. 10. Origin of the paired uteri. Fig. 11. Fully formed paired uteri. *ch.p.*, chitinous pouch; *g.* gonopore; *p.ut.*, paired uteri; *r.ch.p.*, rudiments of the chitinous pouch; *r.v.*, rudiments of the vagina; *v.*, vagina; vii, viii segment numbers; ixs, ninth sternum.

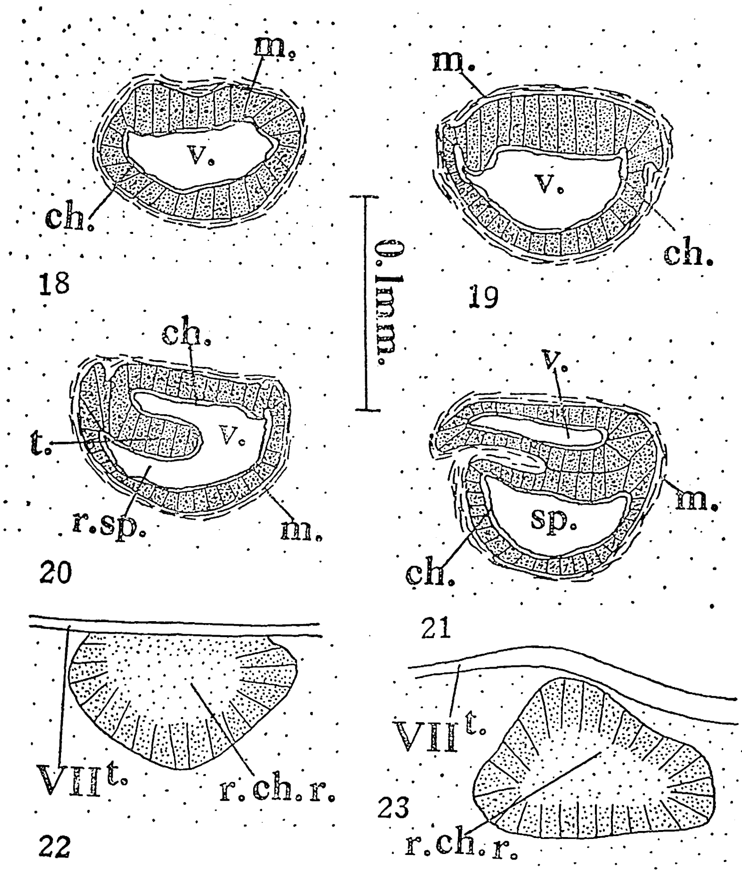
The internal genital organs.—In the early larval instars the internal genital organs consist only of a pair of ovaries which lie in the third and fourth abdominal

segments dorsally to the alimentary canal. At its posterior end each ovary possesses a very small oviduct, which is so small as to extend hardly beyond the fourth segment. As the larva develops into last larval instar there appears a median longitudinal groove over the whole of the eighth sternum. From the



Figs. 12–17. Transverse sections of the posterior part of the abdomen of the pupa from posterior to anterior. Fig. 12. Chitinous pouch with genital palps. Fig. 13. Posterior part of the vagina. Fig. 14. The spermatheca and vagina have a common wall. Fig. 15. Origin of the accessory gland. Fig. 16. Same, a few sections more towards the anterior end. Fig. 17. Anterior part of the vagina, *a.*, alimentary canal; *a.g.*, accessory gland; *ch.*, chitin; *ch.p.*, chitinous pouch; *m.*, muscles; *r.gp.*, rudiments of genital palps; *p.*, spermatheca; *v.*, vagina; viii, ix, segment numbers.

posterior margin of the eighth sternum, the two edges of the groove (Fig. 8, *r.v.*) grow towards the middle line and fuse all along to form a definite tube (Fig. 9, *v.*), which becomes separate from the sternum itself. This tube is the vagina. Anteriorly the vagina gives origin to another pair of tubes (Fig. 10, *p.ut.*) which form the rudiments of the paired uteri (Fig. 11, *p.ut.*). The accessory gland and the spermatheca are not yet developed. The gonopore lies on the eighth sternum.



FIGS. 18–21. Transverse sections of the vaginal tube of the pupa, from posterior to anterior. Fig. 18. Posterior part of the vagina. Fig. 19. Same, a few sections more anteriorwards. Fig. 20. Origin of the spermatheca, the lumen of the vagina shows tongue-like projection in it. Fig. 21. Separation of the spermatheca from the vagina.

FIGS. 22 and 23. Transverse sections of the chitinous rod of the pupa, from posterior to anterior. Fig. 22. Origin of the chitinous rod. Fig. 23. The chitinous rod has separated from the seventh tergum. *ch.*, chitin ; *m.*, muscles ; *r.ch.r.*, rudiments of the chitinous rod ; *r.sp.*, rudiments of spermatheca ; *sp.*, spermatheca ; *t.*, tongue-like projection ; *v.* vagina ; viii, seventh tergum.

In the pupal stage further changes take place. The vagina (Fig. 3, *v.*) extends posteriorly so as to reach the posterior margin of the ninth segment (IX), and

so the gonopore (*g.*) which was situated at first on the eighth sternum now comes to lie on the ninth sternum. At the same time the left wall of the anterior portion of the vagina invaginates to form a horizontal shelf (Fig. 20) which in the transverse sections appears as a tongue-like projection in its lumen. Anteriorly this invagination (Fig. 14) goes on increasing till it meets the right wall of the vagina, and thus two tubes one above the other (*v.*, *sp.*) with a common wall between, are formed (Fig. 13). The ventral tube is the rudiment of the spermatheca the dorsal being the definitive vagina. More anteriorly a horizontal longitudinal slit (Fig. 21) appears in the wall separating the vagina from the spermatheca, and thus the two tubes (Fig. 15) become completely separate. At the anterior end of the spermathecal tube a small bud (Fig. 15, *a.g.*) is produced dorsally, which is the rudiment of the accessory gland. The oviducts which were small in the larval stages grow posteriorly and at the same time the paired uteri which were also very small in the early stages grow anteriorly and thus the oviducts fuse with the uteri of their respective sides, and provide an exit for the products of the ovaries.

When the imago is about to emerge, the spermatheca and the accessory gland assume their adult shape and size, and at the same time the accessory gland which was connected with the spermatheca now separates from it and becomes directly connected with the vagina.

Histology.—In the early larval stages the ovaries are not divided into definite ovarioles. Each ovary consists of a number of cells with well marked nuclei, and all the cells are enclosed in a thin connective tissue membrane. Later, each ovary becomes divided into four groups of ovarioles, each of which is enclosed in a thin membrane, all the ovarioles together being secondarily enclosed in another thin membrane. Posteriorly each ovariole continues into a thin solid cord, and the four cords fuse posteriorly to form a single solid cord which is the rudiment of the oviduct. All these cords are enclosed in a thin membrane just like that of the ovary. Later, each oviduct becomes tubular and its wall consists of a single layer of cells surrounded by a thin connective tissue membrane. In the early stages the vaginal wall consists of a single layer of cells without any kind of muscular covering. The lumen of the anterior portion of the vagina is wider than that of the posterior portion. The structure of the paired uteri is also very similar to that of the vagina, except that the lumen of the latter is wider than that of the former. At a later stage the vaginal wall develops a thick chitinous lining and a muscular covering. Simultaneously the paired uteri also develop a chitinous lining and a muscular covering. The spermatheca has a chitinous lining and a muscular covering from the very beginning. The accessory gland originates as a solid structure, but develops a lumen later on; its wall consists of a single layer of large cells surrounded by a thin muscular coat, but no chitinous lining is developed at any stage.

IV. Discussion

The ovipositor is formed of the eighth and ninth segments and the genitalia, *i.e.*, a chitinous pouch with a pair of genital palps and a chitinous rod.

Opinions differ with regard to the origin of the genitalia. Stein (1847) regarded the chitinous pouch and the genital palps as the divided ninth sternite. Berlese (1882) labelled it as the eleventh segment. Verhoeff (1893) described it as the tenth segment, while Peytoureau (1895) regarded it as the eighth sternum in some and the seventh sternum in other families. These erroneous conclusions were due to the fact that none of these workers had studied the development of these organs. Singh-Pruthi (1924) was the first to study the development of these structures, and he found that a pair of hairy appendages first develop in the larva and that these appendages grow and fuse to form the chitinous pouch. He found similar appendages in the case of the male which he regarded as the coxites of the ninth segment. Similarly he believes that in the female also, these appendages represent the coxites of the ninth segment and the palpi at their apices may correspond to the styli. Metcalfe (1932) found that these appendages are developed from the ectoderm of the ninth sternum; and further, that "from their position, mode of origin and structure, these plates appear to be homologous with the lateral ovipositor lobes in other Insecta, and hence represent the coxites of the ninth segment with the styli". I have shown that these appendages are produced as a pair of groove-like inpushings of the ninth sternum, and that later on these inpushings fuse in the middle line forming the chitinous pouch and that the genital palps are produced as a pair of lateral buds of the chitinous pouch. Thus my observations are in conformity with those of Singh-Pruthi and Metcalfe as regards their origin from the ninth sternum, but I differ from them with regard to their homology. Singh-Pruthi has homologised these structures with the coxites of the ninth segment on the ground that these structures are present in the male along with the telopodites. But Metcalfe and myself do not find the coxites in the male at any stage of its life-history; the male possesses only a single pair of appendages which are really the telopodites. As in the males, there is only a single pair of appendages in the females, and therefore this pair should also be regarded definitely as homologous with that of the male. Thus the appendages of the female genitalia are homologous with the telopodites of the ninth segment. Therefore, whenever a single pair of appendages is present it is homologous with the telopodites of that segment. Verhoeff (1893, Coleoptera) suggested that there is a tendency for the coxites to become closely united with the sternites, eventually losing their identity into the sternite. Therefore the genital appendages should be regarded as the representatives of the telopodites of the ninth segment, and not the coxites.

Metcalfe found that the chitinous rod develops from the sternum of the seventh segment, but my observations show that it develops from the tergum and not from the sternum of the seventh segment.

The internal genital organs.—Singh-Pruthi found that the spermatheca develops from the ninth sternum, and is supported by Metcalfe, but I differ from both of them, as I have found that the spermatheca develops from the uterus and not from the ninth sternum.

Singh-Pruthi believes that the spermatheca is formed earlier than the vagina, while Metcalfe has shown that the two structures originate at the same time. My observations, however, show that the vagina originates at a very early stage and divides later to give origin to the spermatheca.

Singh-Pruthi and Metcalfe found that the vagina originates as an inpushing of the eighth sternum and thus the gonopore lies on the eighth sternum at that stage, and my observations support theirs. But Singh-Pruthi and Metcalfe believe that the vagina and spermatheca fuse posteriorly, and that the opening of the vagina becomes closed, and the adult gonopore is the opening of the spermatheca; but I find that the adult position of the gonopore at the posterior margin of the ninth segment, at the base of the chitinous pouch is obtained by a backward growth of the vagina.

As regards the origin of the paried uteri and the accessory gland, all of us have reached the same conclusion, *i.e.*, the paired uteri are developed from the posterior end of the vagina as paired ducts, while the accessory gland originates from the spermatheca.

In the early stages the oviducts are very small, but they grow and fuse later with the uteri of their respective sides.

Metcalfe believes that all the parts of the efferent system with the exception of the oviducts, are unpaired in origin, but in my opinion the paired uteri should also be regarded as paired in origin, since they originate as paired structures.

V. COMPARISON OF THE GENITAL ORGANS OF THE TWO SEXES

The genital appendages of the female are the telopodites of the ninth segment and are therefore homologous with the primary lobes, *i.e.*, the aedeagus, parameres and the spiculum gastrale of the male. The chitinous rod is peculiar to the female only, of which there is no homologue in the male.

The vasa deferentia of the male are exactly homologous with the oviducts of the female. The other structures of the female efferent and the male efferent system are similar only in that they are ectodermal in development, otherwise their development is absolutely different in the two sexes.

The gonopore in the two sexes cannot be regarded as homologous, since in the early stages the gonopore of the female is situated on the eighth segment, and it is only at a later stage that it comes to lie on the ninh setgment, while in the male it is always situated on the ninth segment from the very beginning.

VI. Summary

The ovipositor consists of the eighth and ninth segments and the genitalia, *i.e.*, a chitinous pouch with a pair of genital palps and a chitinous rod. The chitinous pouch with the genital palps is developed from the ninth sternum and represents the telopodites of that segment, while the chitinous rod is developed from the seventh tergum.

The vagina originates as a median longitudinal groove on the eighth sternum, while the paired uteri develop from the anterior end of the vagina as paired ducts. The spermatheca originates by a horizontal division of the vagina and not independently. The accessory gland develops from the spermatheca as a small bud. In the early stages the gonopore lies on the eighth segment, only later does it come to lie on the ninth segment on account of the backward growth of the vagina.

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NOTES ON *EURYGASTER MAURA* LINN. (PENTATOMIDAE) PEST OF WHEAT CROP IN INDIA, WITH KEYS TO ITS VARIETIES AND TO THE SPECIES OF *EURYGASTER* LINN.

By C. K. SAMUEL, B.SC., ASSOC. I.A.R.I.

Assistant Systematic Entomologist, Indian Agricultural Research Institute, New Delhi

INTRODUCTION

Eurygaster maura Linn. (the 'corn bug') is an important pest of wheat crop in the Palæarctic Region and there are numerous records of its occurrence in epidemic form in Hungary, Italy, Central Europe, Southern Russia, etc. In India the first report of its occurrence on wheat was received by the Imperial Entomologist from Kulu (Punjab) in 1926. The pest was also reported to occur in the Zhob valley (Fort Sandeman, Baluchistan) consecutively in the summers of 1940–43. In order to collect first-hand information regarding the nature and extent of damage by the pest to wheat crop in India, the author visited some important wheat-growing centres of Baluchistan. The observations based on a survey of this pest during the summer of 1943 are briefly set forth in this paper.

NATURE AND EXTENT OF DAMAGE

TABLE *showing the extent of damage caused to wheat by the different varieties of* Eurygaster maura *in Baluchistan during April–May*, 1943

No.	Locality	% Damage to ears	Damage to grains in ears	No. of bugs found per plant	Proportions of the various varieties doing damage in association					
					Var. *maura*	Var. *picta*	Var. *personata*	Var. *pallida* Yellow	Var. *pallida* Brown	Var. *nigra*
i	Quetta (5,490 ft.) ..	nil	nil	nil	..	..	..	..	..	..
ii	Fort Sandeman or Zhob valley (4,614 ft.)	10–25	26–35	1–8	18%	12%	7%	20%	30%	13%
								50%		
iii	Loralai (4,699 ft.)	nil	nil	nil	..	..	..	..	..	..
iv	Barkhan (Loralai District) (3,650 ft.)	10–15	5–10	1–6	22%	18%	5%	25%	16%	14%
								41%		
v	Kohlu (Sibi District) (4,600 ft.)	50–90	30–100	1–12	12%	8%	5%	24%	35%	10%
								59%		

The foregoing TABLE shows that maximum damage to wheat ears (50–90%) and to grains (30–100%) was caused in Kohlu area and that the variety *pallida*

was predominant (59%) in that locality. The extent of damage to ears and grains in Fort Sandeman was 10–25%, 20–35% and in Barkhan 10–15%, 5–10% respectively; *pallida* correspondingly predominated to the extent of 50% and 41% respectively in these two localities.

NATURAL ENEMIES

The fifth instar nymphs of the various varieties were observed parasitised by a Sarcophagid (*Sarcophaga* sp.); the pupal period of the parasite was about a week during May. The degree of parasitism was rather very low being only 0·5 to 1·5%. The Indian house-sparrow, *Passer domesticus indicus* was seen feeding on the adults and nymphs of the various varieties of *E. maura* at Barkhan and Kohlu during April–May.

COLLECTION AND IDENTIFICATION OF THE PEST

Since a large number of differently coloured bugs were found together doing similar damage to the milky ears in the field, *i.e.*, by causing them to turn silvery white in contrast to the unaffected green ears, it was suspected that several species or at least different forms or varieties of one species may be concerned. With this object in view, a large series of specimens of the pest were collected by the author at different times of the day from the localities mentioned in the TABLE, and brought to New Delhi for comparison with the specimens of the Imperial Pusa Collection. In the I. P. Collection, similar bugs with different colour markings have been grouped together under the common label "*Eurygaster maura?*" and their details are given as follows:—

(i) On wheat, Mosul, June 1919, Wimshurst Coll. (2 specimens, light yellow); (ii) On wheat ears, Karradah Farm, 23–5–1920, Y. R. Rao Coll. (1 spn., light yellow); (iii) On wheat, Fort Sandeman (Baluchistan), May 1941 (1 spn., black); (iv) On wheat, Fort Sandeman (Baluchistan), May 1941 (5 spns., dark brown); (v) Adult on wheat head, Kulu (Punjab), 12–6–1939, U. Bahadur (2 spns., dark brown); (vi) Damaging wheat crop, Zhob valley (Baluchistan), Agricultural Officer, 17–6–1940 (3 spns., dark brown); (vii) Fort Sandeman, P. A. garden, June 1937, Rashid Din Mohd. Coll. (2 spns., black including 1 nymph); (viii) On wheat ears, Barkhan, Kulu, 12–6–1939, Sardar Singh Coll. (1 spn., dark brown).

Distant's (1902) description of this species is rather incomplete as it does not give the distinguishing morphological features of the varieties, and it is as follows:—'Ochraceous, more or less suffused with dark or purple-brown and thickly and darkly punctate; connexivum with large quadrate dark spots formed almost uniform ochraceous to luteous with fasciae and suffusions of various shades of brown, in some varieties nearly almost suffused with dark brown.' He further adds that 'Scopoli (*Ent. Carn.*, p. 120) states that in all the varieties the colour of the undersurface is always the same, but this cannot be maintained.'

In Baluchistan there are at least five varieties, *viz.*, *maura*, *picta*, *personata*, *nigra* and *pallida* of one species, *E. maura* concerned in damaging the wheat crop, and this is the first record of so many forms occurring in India.

KEY TO SPECIES OF *Eurygaster* LINN. ADAPTED FROM STICHEL (1925, 1938)

1 (4) Frontal carina free.

2 (3) Frontal carina and cheeks lie at the same level everywhere. Cheeks slightly bulged outside. The second antennal segment about twice as long as the third. Lateral angles of pronotum rounded. Pronotum often with an indistinct transverse furrow. Colour bright to dark brown. Length 9–10 mm. Commonly found on *Artemisia campestris*, *Centauria*, *Senecio carduus*, *Secale*, *Erica*, *Juniper*, etc. Also on cereals and flowers of several other wild plants in sunny and damp grassy plains probably occurring all over Germany.—*maura* Linn.

3 (2) Frontal carina distally somewhat covered by the cheek at sides. Cheeks outside straight or slightly bulged. Second antennal segment $1\frac{1}{2}$ times as long as third. The lateral angles of pronotum somewhat projecting and acutely rounded. Transversely furrow of pronotum, in middle wholly indistinct or absolutely lacking. Colouration, length and occurrence similar to foregoing species (*maura*) with which it is often found confused. So far known from Macklenburg, Holstein, Hannover, but certainly occurs in other districts also.—*testudinaria* Geof.

4 (1) Frontal carina completely enclosed by the cheeks.

5 (6) Antennae light blown or partly light brown and partly dark brown. Fifth segment black. Median line of scutellum elevated like a carina and distinctly visible. Length 11–13 mm. The species occurs in dry and sandy soils on *Verbascum*, *Salvia*, *Thymus*, *Artemisia*, etc. It is recorded from Prussia, Silesia, Posnen, Brandenburg, Mecklenburg, Holstein, Saxony, Thuringia, Westfalia, Rhineland, Alsas Lorraine, Baden, Bavaria and Würtemberg.—*austriaca* Schrk.

6 (3) Antennae bright brown, 4th and 5th segments black. Median line of scutellum almost invisible. Length 9 mm. Recorded from Bavaria. —*fokkeri* Put.

CHARACTERS OF THE VARIETIES OF *E. maura* LINN. ADAPTED FROM STICHEL (1925, 1938)

(*a*) Upper side yellowish brown with transverse rows of scattered dark spots on prothorax. The two smooth areas at base of scutellum brownish. Size $12 \cdot 66 \times 7 \cdot 66$ mm.—var. *maura* L.

(*b*) Upper surface brownish red or blackish. Pronotum and scutellum with irregular bright stripes, composed of deeper and bigger spots than in var. *maura*. Size $13 \cdot 00 \times 7 \cdot 66$ mm.—var. *picta*.

(*c*) Upper surface brown. Posterior part of the pronotum with a broad black longitudinal stripe which is vertically and widely broken at various points. Before the posterior angles there is a semi-circular brown spot. The two smooth areas at base of scutellum white. Size 13·00 × 7·66 mm.—var. *personata* Stich.

(*d*) Upper surface black. Ventral surface of abdomen brown to dark brown with a central broad black stripe intercepted by segments. Trochanter and tarsii bright brown. Antennæ bright, terminal segment of antennae black. Size 13·20 × 7·50 mm.—var. *nigra.*

(*e*) Upper surface black, pronotum in front with two yellow triangular spots. Legs yellowish. Antennæ yellowish, 4th and 5th segments brown. Abdomen brownish yellow and with brown spots over the stigmata.—var. *signata* Fieb.

(*f*) Upper side grey, third antennal segment almost black, connexivum almost impunctate.—var. *grisescens* Rey.

(*g*) Upper side finely punctate and with minute smooth areas.—var. *granulosa* Wagner.

(*h*) Upper surface dark brown to black. Smooth areas on base of scutellum bright.—var. *nigricans* Manc.

(*i*) Upper surface ochre-yellow to bright brown. Punctation colourless. Size: yellow 13·33 × 7·50 mm.; brown 13·00 × 8·00 mm.—var. *pallida* Wagner.

(*j*) Like in type form *maura* but with a reddish tint—var. *rutila* Wagner.

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STUDIES IN THE ASSOCIATION OF PLANT CHARACTERS AND PEST INCIDENCE: II. ON THE RELATIONSHIP BETWEEN SPINDLE LENGTH AND VARIETAL RESISTANCE TO TOP BORER ATTACK IN SUGARCANE*

By K. L. Khanna and K. R. Ramanathan
Central Sugarcane Research Station, Pusa (Bihar)

I. Introduction

Of all the various pests attacking sugarcane in India, the one generally responsible for causing the greatest loss is the top borer, *Scirpophaga nivella* Fabr. This borer causes injury to the cane by boring through the topmost spindle portion (Plate I), consisting of the bases of leaves, and attacking the growing point. This results in the stoppage of further growth of the shoot and subsequent drying up of the cane. Different varieties show different susceptibilities to the attack of this borer, some of them, like *Co.* 331 and *Co.* 453, if not immune from attack, generally showing a lesser, overall susceptibility than varieties like *Co.* 213 or *Co.* 508. As to what these varietal characters are, which actually bring about these variations in susceptibility, very little is known. Hazelhoff (1932), from a study of a few varieties in Java, suggested that the percentage of dry matter in the spindles might play an important role in determining the ease with which larvae can penetrate into the cane and can thus be used as an index of borer resistance or susceptibility of the varieties. A similar suggestion was made by Tucker (1933, 1937) with respect to the stem borer, *Diatraea saccharalis* Fabr. Isaac (1939), and more recently, Thuljaram Rao and Venkatraman (1941) suggested that the hardness of the midrib may be used as an indication of the resistance or susceptibility of a variety, since the top borer larva invariably entered the shoot through the midrib and any resistance offered by the tissues of the mid-rib to its entry must have a direct influence on borer infestation.

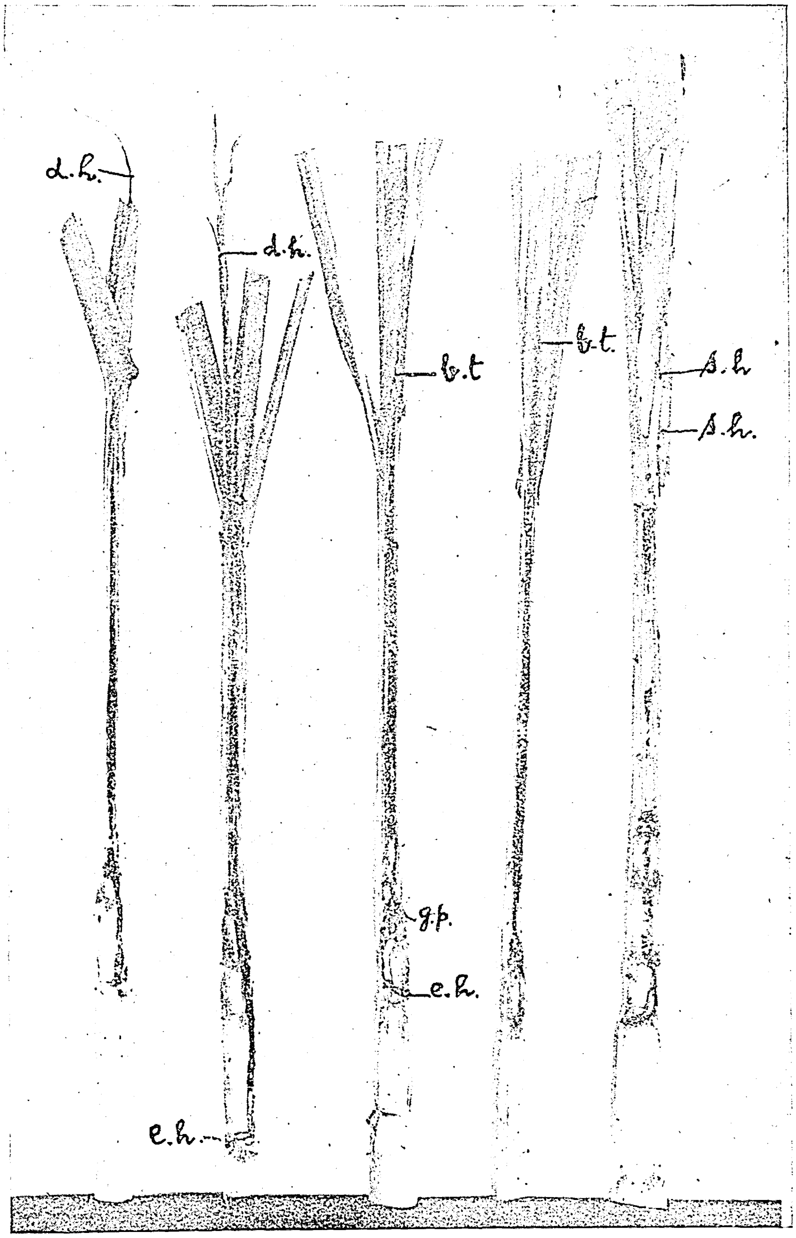
While the above features may have some influence on the degree of borer infestation in different varieties, they are not easily determinable without some laboratory or microscopic examination. Any other varietal character, which, in addition to indicating a fairly close relation to the varietal susceptibility, could also be determined without recourse to an elaborate laboratory or microscopic examination, should greatly facilitate classifying varieties with reference to this important pest.

II. Observations

Observations undertaken with the above object in view, on the habits of different sugarcane varieties in relation to this pest, during different parts of the

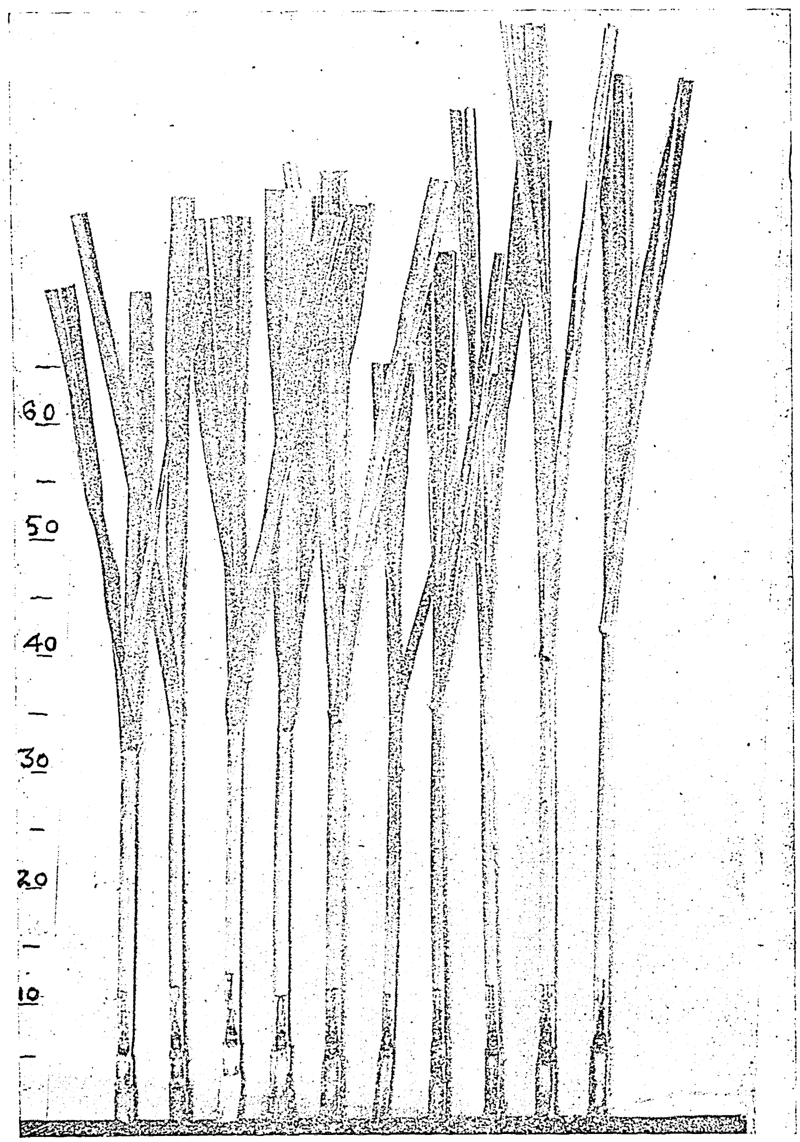
* The first part, entitled, 'Nature of leaf surface and mite attack' appeared in the *Proc. Nat. Inst. Sci. India,* 1947, **13** (6).

PLATE I



Top portion of different cane varieties showing the mode of attack by the top borer larva The borer tunnel (*b.t.*) in the midrib and its passage down the spindle up to its place of exit through one of the younger internodes below growing point (*g.p.*) is clearly seen. (*b.t.,*) borer tunnel inside the midrib; *e.h.*, exit hole; *d.h.*, dead heart,; *s.h.* shot holes).

PLATE II



a *b* *c* *d* *e* *f* *g* *h* *i* *j*

Top portion of different cane varieties showing variation in "effective length" in relation to top borer attack. The leaves have been trimmed to 1/3 their full length and growing part exposed to show variation in spindle length in different varieties. (*a*) Co 508, (*b*) Co 313, (*c*) Co 213, (*d*) Co 383, (*e*) Co 421, (*f*) Co 513, (*g*) Co 395, (*h*) Co 285, (*i*) Co 453, (*j*) Co 331.

year and under varying environmental conditions at Pusa, suggested that the variations often seen in the length of spindle (Plate I), (*viz.*, the distance between the growing point and the last exposed transverse mark) and also in the length of the leaf, might show a fairly close relation to the variations seen in the top borer incidence. The top borer, in order to make a successful attack on the plant, will need to bore through a certain amount of distance, from the point of its entry into the midrib of one of the topmost unfurled leaves, to the growing point enclosed far below inside the spindle (Plate I). Naturally the time taken to reach the growing point will greatly vary with the amount of distance the larva has to traverse; the greater the distance, the longer the time taken and greater the trouble and resistance encountered in reaching the growing point. Consequently, varieties which have, in general, a longer spindle and a longer leaf must reasonably be expected to afford greater resistance to an easy attack by the top borer than those having a shorter spindle and shorter leaf. Of these two characters, evidently the spindle must be expected to exert a greater influence than the leaf, since in addition to its greater compactness, it is at the same time actively growing, by the meristematic activity of the portions lower below and thus actively able to resist the boring activity of the larva.

The above suggestions were tested during 1946 and 1947 by recording observations on different varieties at different periods of the year corresponding to different broods of the borer and under different conditions of environment. Every time twenty canes of more or less equal age were selected at random, for each of the varieties studied and measurements were recorded for the length of their spindle and the length of the standard leaf. Since earlier studies at this station (Khanna, 1942) on the habit of the top borer had shown that it usually made its entry into the midrib of the topmost unfurled leaf, within about $\frac{1}{3}$ the length of the leaf from the transverse mark, the approximate distance a larva will have to bore through in different varieties, in order to make a successful attack, has been taken as equivalent to the sum total of the spindle length plus $\frac{1}{3}$ the length of the standard leaf. This total length is designated here as "effective length".

A perusal of the data collected so far (Tables I and II) brings out clearly that not only the different varieties studied show significant differences in the average lengths of their spindle and leaves at different periods of the season, but also a high negative correlation with the average borer incidence during this period. It is interesting to note that varieties like *Co* 213, *Co* 508 and *Co* 313, all well known for their high susceptibility to top borer attack, show generally a shorter spindle length compared to varieties like *Co* 331 and *Co* 453 (Plate II) which show a comparatively greater resistance. Further, of the three characters studied, the relationship of the borer incidence with spindle length is of a higher order than that with the other characters as indicated by the value of the coefficient of correlation obtained with the above feature.

TABLE I. *Average length of the standard leaf, leaf spindle and 'effective length' in different sugarcane varieties at three different periods of the season* 1946–47

Serial No.	Character: Period / Varieties	Average length of leaf (cm.) July 1946	Aug. 1946	Sept. 1946	Av. for 3 periods	Average spindle length (cm.) July 1946	Aug. 1946	Sept 1946	Av. for 3 periods	Average effective length (cm.) July 1946	Aug. 1946	Sept. 1946	Av. for 3 periods
1	Co. 213	121·7	116·8	118·2	118·88	26·25	24·35	23·33	24·64	66·82	63·28	62·73	64·27
2	Co. 285	125·3	139·6	130·6	131·80	29·75	29·20	26·98	28·64	71·52	75·73	70·51	72·97
3	Co. 313	127·9	138·3	136·9	134·35	26·00	24·83	26·05	25·63	68·63	70·93	71·68	70·41
4	Co. 331	132·5	163·8	155·6	150·63	29·20	30·63	30·22	30·02	73·37	85·23	82·09	80·23
5	Co. 383	128·1	139·6	134·6	134·05	24·88	27·10	24·38	25·45	67·58	73·63	69·25	70·15
6	Co. 395	129·5	130·7	130·3	129·48	27·13	26·00	25·15	26·09	69·63	69·40	68·58	69·20
7	Co. 421	142·1	139·8	137·3	139·70	26·85	29·20	26·65	27·57	74·22	75·80	72·42	74·15
8	Co. 453	148·2	163·5	160·1	157·25	30·65	32·50	29·30	30·82	80·05	87·00	82·67	83·24
9	Co. 508	109·6	108·8	110·7	109·67	25·30	25·18	22·75	24·41	61·83	61·45	56·32	59·87
10	Co. 513	117·1	126·9	129·1	124·35	26·60	27·30	25·25	26·39	65·63	69·60	69·28	67·84
(*a*)	S. E. of diff. between means (var.) ±	3·41	2·96	3·32	1·992	0·75	0·81	0·65	0·444	2·11	1·88	1·28	0·799
(*b*)	C.D. at 5% level of significance (between var.)	6·68	5·80	6·50	3·90	1·47	1·59	1·27	0·87	4·14	3·68	2·51	1·57
(*c*)	S. E. diff. between means (periods)				±1·092				±0·243				±0·438
(*d*)	C.D. at 5% level of significance (between periods)				2·14				0·48				0·86

TABLE II. *Relation between the average leaf length, spindle length and 'effective length' in different sugarcane varieties and their average top borer incidence during three periods of the season (July, August and September)* 1946–47

Characters studied*	Co 213	Co 285	Co 313	Co 331	Co 421	Co 453	Co 508	Co 513	Corr. coeff. with character (D)
A. Average leaf length (cm.)	118·88	131·80	134·35	150·63	139·70	157·25	109·67	124·35	−0·7817†
B. Average spindle length (cm.)	24·64	28·64	25·63	30·02	27·52	30·82	24·41	26·39	−0·8322†
C. Average effective length (cm.)	64·27	72·57	70·41	80·23	74·15	83·24	59·87	67·84	−0·8083†
D. Average % of top borer incidence (1946)	33·97	30·38	31·86	25·37	30·22	20·99	33·71	25·59	..

* All the averages are for three periods, July, August and September, 1946.
† Significant at 5% level.

A study of some of the indigenous sugarcane varieties also gave similar results (Table III). Forms of Mungo group, with their longer spindle showed generally a lower susceptibility to top borer incidence than those of the Nargori, Pansahi or Saretha groups with comparatively shorter spindle lengths. Within each group, however, different varieties showed varying lengths, indicating individual varietal characteristics.

TABLE III. *Showing average leaf length, spindle length and effective length in eight indigenous cane varieties at two periods of the season August and October*, 1946

Character	Av. length of leaf			Av. spindle length			Av. effective length		
Periods / Varieties	August 1946	October 1946	Av. of two periods	August 1946	October 1946	Av. of two periods	August 1946	October 1946	Av. of two periods
1 Hemja ..	119·4	119·5	119·45	31·50	32·35	31·98	71·30	72·18	71·80
2 Bhurli ..	125·8	125·9	125·85	32·75	33·00	32·88	74·73	74·97	74·83
3 Pansahi ..	113·0	106·0	109·50	22·10	19·10	20·60	59·77	54·43	57·10
4 Uba ..	117·5	105·5	111·50	23·15	20·35	21·75	62·37	55·52	58·92
5 Chin ..	121·2	102·8	112·00	22·50	16·65	19·58	62·90	50·92	56·91
6 Saretha ..	145·7	133·6	139·65	32·10	26·15	29·13	80·67	70·62	75·68
7 Sewari ..	96·2	80·0	88·10	18·60	16·50	17·55	50·67	43·17	46·92
8 Baraukha ..	82·5	92·9	87·70	19·50	17·50	18·35	46·70	48·47	47·58
S.E. (varieties)	±1·92 : C.D. at 5% 5·31			±0·09 : C.D. at 5% 0·25			±0·64 : C.D. at 5% 5·18		
S.E. (periods)	±0·95 : C.D. at 5% 2·63			±0·05 : C.D. at 5% 0·14			±0·31 : C.D. at 5% 0·86		

III. DISCUSSION

While the above observations indicate a close relationship between the spindle length and top borer incidence, it must be pointed out that this relationship is not absolutely proportional or uniform under all conditions, as varietal characters like the ones suggested above, are quite often subject to variations under varying edaphic and climatic conditions and the effect of such variations are not always similar on the pest and the host. In fact the pest-host complex reacts frequently in opposite directions resulting in apparently divergent results. Besides, there are other features of the plant which may also influence the susceptibility or resistance of a variety towards borer attack in different directions so much so that the effect of any one feature may be somewhat masked or modified by the other. Thus, in the present instance, *Co* 513, in spite of its having a shorter spindle length than that of *Co* 285 or *Co* 421, was found to show generally a lower susceptibility to top borer attack than the latter varieties. This is evidently due to some other advantageous feature that *Co* 513 possesses, in addition to the spindle length. Preliminary observations on this aspect have shown that the relatively greater spreading nature of the leaves seen in this variety and the consequent inability of the moth to lay its eggs easily, is responsible for the lower incidence compared to other varieties. Lastly, there is one other disturbing element in respect of this relationship and that is the differential susceptibility to top rot (*Fusarium moniliforme* Sheld.) of different varieties. This disease is at its worst (Khanna, 1941) during the July–August period when top borer incidence also reaches its peak. As a result of top rot attack, there is a great abbreviation in the length of the leaf and the spindle, resulting in an easy penetration and destruction of the growing point by the top borer. Thus the higher incidence, recorded for *Co* 421 and *Co* 331 towards August–September period, is due largely to their greater susceptibility towards top rot attack during this period.

In spite, however, of the variations described above, the above character is found to be one of those desirable characters, which in combination with other economic characters could profitably be used, as an indicator in selecting a suitable variety for regions where attack by the top borer is a major problem.

IV. SUMMARY

The paper records some observations made on certain plant characters associated with top borer incidence in sugarcane. It has been shown that a high negative correlation exists between the susceptibility of a sugarcane variety to top borer attack and the length of its spindle and leaf, the former showing a much higher value than the latter. Varieties with longer spindle and longer leaf exhibited a greater resistance than those with shorter spindle and leaf. While such a relationship has been found to hold good for a fairly large number of varieties belonging to Coimbatore canes and indigenous cane groups, the likely influence of other plant attributes, such as the spreading nature of the tuft in

either masking or modifying the effect of spindle length, has been stressed. Further, the differential susceptibility of varieties to top rot disease has been shown to greatly increase the top borer incidence by considerably abbreviating the spindle length and by affording easy access to the top borer. In conclusion, the significance of the spindle length as a desirable character along with other economic attributes in selecting a suitable variety for regions liable to severe top borer damage has been pointed out.

V. Acknowledgements

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ON REDDISH PIGMENTS IN EGGS, OVARIOLES, EMBRYONIC EYES, ETC., IN THE DESERT LOCUST, *SCHISTOCERCA GREGARIA* (FORSKÅL) [ORTHOPTERA, ACRIDIDAE*]

By HONY. MAJOR M. L. ROONWAL, M.SC., PH.D. (CANTAB.), F.N.I.
Zoological Survey of India, Indian Museum, Calcutta

CONTENTS

I. INTRODUCTION

Künckel d'Herculais (1892) showed that immature adults of the desert locust, *Schistocerca gregaria* (Forskål), are deep pink in overtone and the mature ones yellowish. Before him the two colour-stages were regarded as due to differences in the geographical origin of the individuals. He relegated the pink pigment to the group of "zoonérythrine", otherwise known as carotinoids—a conclusion confirmed by Chauvin (1938–1939*b*). After the development of the phase theory (Uvarov, 1921) and its application to the desert locust (Uvarov, 1923), Johnston (1926) showed that the pink colour is characteristic of *gregaria* phase only and does not occur in *solitaria* adults, the latter being greenish when young and greyish later—a conclusion which I have been able to confirm in the field. I have further noticed (1945*b*, 1946*a*) that *solitaria* adults are greenish during the first few days after eclosion, but later, two colour-types can be distinguished thus: the majority (about 91%) are suffused with a blue-grey tinge, while the remainder lack this tinge entirely and are buff to fawn.

Faure (1932), in *Locusta* and *Locustana*, postulated the presence of a theoretical substance, *locustine*, which he believed to be responsible for phase production and which could be transmitted from one generation to the next through the medium of the egg-substance. Chauvin (1938*a*, 1939*b*) demonstrated in the desert locust the presence of a brown pigment, *acridioxanthine*, in the hypodermal cells of *gregaria* adults and its absence in *solitaria* ones. He remarked that this substance may be the locustine of Faure unless the latter is identical with the melanin of phase *gregaria* which too, like acridioxanthine, is absent in phase

* For a preliminary account see Roonwal, *Nature*, **156** (1945): 19.

solitaria. Chauvin (1939) also showed that the pink pigment ejected by the desert locust with the excreta at each moult, except the first and specially at the final moult, is also acridioxanthine analogous to the hypodermal pigment and only slightly differing from it. Vayssiére and Lepesme (1939) found in the desert locust that laboratory-bred hoppers in *gregaria* and *transiens* phases are sometimes suffused with a pink tinge. Finally, I had reported several years ago (Roonwal, 1936 *a*) that the eye-pigment in *Locusta* first appears in the embryo as a deep orange-red mass and gradually turns brown before hatching.

It will thus be seen that pink and orange-red pigments appear to play a considerable role in the body-coloration of the desert and other locusts, specially in phase *gregaria*. The fact that melanin, whether black or brown, generally passes through a red phase in the early stages of its production gives an added phase-significance to the presence of reddish pigments, for melanin is present in large quantities in *gregaria* and absent in *solitaria* individuals.

Besides the phase variations of Uvarov (1923, 1928), various other types of variations have, in recent years, been shown to exist in the desert locust by the writer (Roonwal, 1936–1949*a*). Here will be described, firstly, the occurrence of reddish pigment of apparently similar properties in the eggs and ovarioles of the desert locust, and its probable phase significance discussed. Secondly, the production and probable significance of pink colour in young hoppers by exposure to chloroform vapour will be discussed. Thirdly, the production of reddish pigments in embryonic eyes and in adults will be considered.

II. Pink Pigment in Eggs

While breeding the desert locust under semi-natural conditions, I noticed that some eggs were suffused superficially with deep pink, whereas others lacked that pigment. Generally all the eggs in a pod were of one category—either pink or non-pink—though a few exceptions were also noticed. The two kinds are characterised as follows:

Pink eggs.—The pink pigment is present on the chorion in irregular patches and streaks, the colour deepening when the egg is dried. If the chorion is peeled off, the pink pigment is removed with the egg-wall. The inner cuticle of the egg-wall, the embryo and the yolk show, as a rule, no trace of pink, though in one or two shrivelled or half-dried eggs the embryo was found to be deep pink. Young eggs are brown with a pink tinge. Older eggs, about to hatch, are dark brown with a reddish tinge in the egg-wall, and are more or less opaque.

Non-pink eggs.—There is no trace of pink. Young eggs are pure, almost golden, brown. Older eggs appear greenish and are somewhat translucent.

Egg-colour in possible relation to colour and phase of hoppers.—The colour of hatching, *i.e.*, of first stage hoppers, derived from known types of eggs, was recorded (Table 1), allowing some hours for the development of colour. Three colour-categories of hoppers were recognized for this purpose, thus: (i) black

or *gregaria*, (ii) intermediate and (iii) green or *solitaria*. Taken together, 185 pink eggs produced 54% black, 22% intermediate and 24% green hoppers. The corresponding figures for 406 non-pink eggs were 25%, 17% and 58%. These proportions would suggest that pink eggs produce a majority of black hoppers, and non-pink eggs a majority of green. On the other hand, hatchings from some 172 eggs belonging to 5 pods contradict this conclusion. Thus, in Pod No. 29 the eggs were pink, yet the majority of the resulting hoppers were green; in Pod Nos. 24, 35, 40 and 42 the eggs were non-pink, yet all or the majority of the resulting hoppers were black.

TABLE 1. *Egg-colour and the colour and phase of hatchings*

Egg-colour	Egg-pod No.	Number of hoppers in each category			Total hatched	Number died before hatching
		Black (*gregaria*)	Intermediate	Green (*solitaria*)		
Pink	28	28	0	20	48	18
	29	3	3	15	21	25
	33	34	13	5	52	2
	37	24	3	1	28	0
	39	12	21	3	36	0
	Total:	101	40	44	185	45
	% in each category:	54%	22%	24%	80%	20%
Non pink	30	2	6	13	21	14
	31	0	0	46	46	2
	32	0	0	50	50	0
	34	10	14	7	31	7
	35	38	0	0	38	0
	36	5	7	29	41	0
	38	1	15	35	51	3
	40	16	5	3	24	6
	41	0	0	46	46	0
	42	32	21	5	58	0
	Total:	104	68	234	406	32
	% in each category:	25%	17%	58%	93%	7%

Mortality.—Pre-hatching mortality among the embryos (Table 1) appears, on the average, to be higher in the case of pink eggs (20%) than in that of non-pink eggs (7%).

III. ORANGE-RED PIGMENT IN OVARIOLES

1. *The Desert Locust*

In desert locust females, both laboratory-bred and caught in nature, there was found a granular mass of organe-red pigment* at the base of several, some-

* Often referred to hereafter as "red" or "reddish", for the sake of brevity.

times all, ovarioles. The pigment lies in a small basal chamber or pedicel which lies between the basal egg-follicle and the egg-calyx and abuts on the latter (Fig. 1).

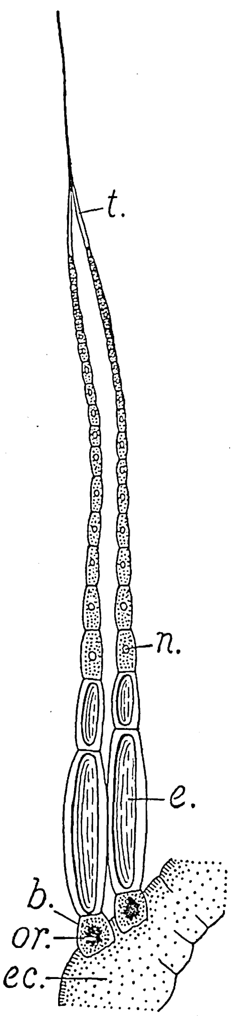

FIG. 1. *Schistocerca gregaria* (Forskål).—Two ovarioles from the ovary of a half mature adult, showing the orange-red mass of pigment in the pedicel. × about 12. *b.*, basal chamber or pedicel; *e.*, egg; *ec.*, egg-calyx; *n.*, nucleus; *or.*, mass of orange-red pigment; *t.*, terminal filament.

Dissections of adults, made to determine the relation of the reddish mass to age, number of eye-stripes (*vide* Roonwal 1936 *et seq.*) and phase, gave the following results:

(*a*) PHASE SOLITARIA

D 1.—7 eye-stripes. Mature ♀ with ripe eggs. Red mass present in most ovarioles, being large in those with young basal eggs and very small or hardly visible in those with large, ripe eggs.

D 2.—7 eye-stripes. Mature ♀ with ripe eggs having descended into egg-calyx. Red mass present in all ovarioles.

D 3.—7 eye-stripes. Very old laboratory-bred ♀ having previously oviposited several times; no ripe eggs present. Red mass present in almost all ovarioles.

D 4.—6 eye-stripes. Old ♀ with no ripe eggs. Red mass present in all ovarioles.

D 5.—6 eye-stripes. Mature ♀ with ripe eggs having descended into egg-calyx. Red mass present in a few young ovarioles with small eggs; the rest without the red mass. No trace of red pigment in the ripe eggs lying in egg-calyx.

(*b*) PHASE GREGARIA

D 6.—6 eye-stripes. Very old laboratory-bred ♀ probably having oviposited several times; no ripe eggs present. Red mass present in most ovarioles.

D 7.—6 eye-stripes. Freshly eclosed ♀ bred in laboratory from black, gregariously reared hopper. No trace of red mass in ovarioles.

Dissections of hoppers gave the following results:

H 1.—Late fifth stage, black (*gregaria*), with 5 eye-stripes. Ovarioles transparent and colourless, with no trace of red pigment.

H 2.—Late fifth stage, green (*solitaria*), with 5 eye-stripes. Ovarioles as in *H* 1.

H 3.—Fourth stage, green (*solitaria*), with 5 eye-stripes. Ovarioles as in *H* 1.

In some other dissections of some 40 fourth stage hoppers, though no records were preserved, my distinct recollection is that the red pigment was absent from the ovarioles.

It is tentatively concluded that: (i) the red pigment of the ovarioles has no apparent relation with the eye-stripe variation, being present in both 6- and 7-striped individuals; (ii) it is present in both *solitaria* and *gregaria* adults; and (iii) its absence in older hoppers and in the single immature adult examined suggest that it develops only with maturity. On the other hand, in a ripe female (*D* 1) the ovarioles with young basal eggs had a well-developed red mass whereas those with ripe eggs had the red mass either feebly developed or absent.

Dissections of *gregaria* (late April) and *solitaria* (various months) males showed the absence of reddish pigment in the testes.

2. *The Rice Grasshopper*

Several dissections of brachypterous females of *Hieroglyphus nigrorepletus* Bolivar from Benares* showed the presence of orange-red granular masses at the base of the ovarioles (Fig. 2), exactly as in the desert locust. As a rule, only a few ovarioles in an ovary carried this pigment.

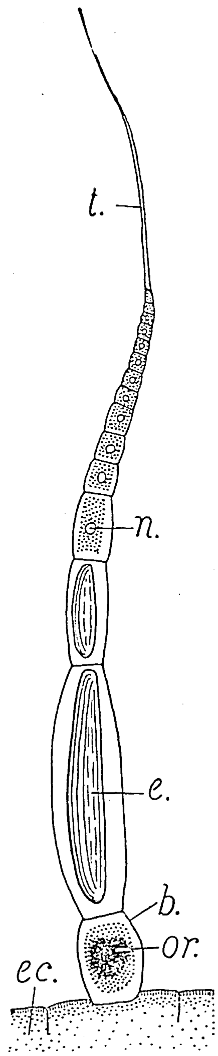

FIG. 2. *Hieroglyphus nigrorepletus* Bolivar, forma *microptera* (short-winged). An ovariole from an immature adult, showing the orange-red mass of pigment in the pedicel. × about 32. Lettering as in Fig. 1.

IV. PINK COLOUR IN HOPPERS PRODUCED BY CHLOROFORM VAPOUR

Hoppers of the desert locust, whether green or black, normally carry no pink in the body-wall at any stage, though exceptionally (*vide* Vayssiére and Lepesme, 1939) this may be developed. Freshly hatched hoppers are almost colourless. Within a few hours of hatching they develop a black, intermediate or green colour-pattern, depending to a considerable extent on the phase of the parents. All three types are generally present in an hatching. But, as a rule, *gregaria* parents produce more black and *solitaria* parents more green hoppers. When freshly hatched hoppers, whether immediately on hatching or a few hours afterwards, are exposed to chloroform vapour, they quickly develop pink patches in the cuticle and at the same time become inactive. Hatchings from three egg-pods, Nos. 28, 33 and 40 (see Table 1), were used for the purpose, with the following results:

(i) Black hoppers became deep pink, and green ones light pink. Where the normal pattern had partially developed, those hoppers in which a black pattern was evidently developing acquired a deeper pink than the others.

* Breeding occurs here in August-September (*vide* Roonwal, 1945*d*).

(ii) In green hoppers the pink developed first and was deeper in those areas which corresponded to the dark or black areas in the black hoppers, *e.g.*, antennae, legs and the dorsal portions of the head, thorax and abdomen. In other areas, which roughly corresponded to the non-black areas in the black hoppers, the pink was either much fainter or not developed at all.

These results suggest two things: (*a*) The deep pink developed by chloroform vapour marks the black or melanin bearing areas in the cuticle of the black hoppers. (*b*) In the cuticle of green hoppers the "black" areas are present in an undeveloped state as a kind of substrate, only waiting to be developed into visible black areas by some chemical (enzymic ?) action brought about by the factors which produce the *gregaria* character.

Revival of hoppers.—A few hours after hatching, 47 first stage hoppers (28 black, 19 green) from the same hatching (Pod No. 28) were together subjected to chloroform vapour and soon became inactive. At the same time, the black hoppers became deep pink and the green ones light pink. A few minutes later, all the hoppers were placed in fresh air. None of the 28 black (deep pink) hoppers revived; of the 19 green (light pink) ones, 11 recovered fully and 8 died. It would thus appear that black hoppers, probably because of their faster metabolism, are more sensitive to chloroform vapour than green ones.*

V. Reddish Pigment in Embryonic Eyes and in Adults

Embryonic eyes.—The eye-pigment in the desert locust first makes its appearance in the embryo shortly before blastokinesis as an organe-red area along the posterior margin of the eye, exactly as demonstrated earlier (Roonwal, 1936*a*, p. 415) in *Locusta migratoria migratorioides.* It gradually turns brownish and spreads all over the eye before hatching. In black first stage hoppers the brown pigment is visible externally, the eye appearing deep brown. In the green hoppers the eye is at first colourless, except for the chocolate-coloured dorsal spot which is present also in black hoppers. A few days later, a brown stripe appears mid-dorsally beneath the dorsal spot and gradually extends to the lower margin of the eye; more brown stripes develop with moulting (*vide* Roonwal, 1937, pp. 25–26 and 150–151; 1947). Thus, the brown eye-pigment first develops as an orange-red pigment.

The probability that this red pigment is the precursor of melanin (brown) of freshly hatched hoppers is strengthened by what has been shown in other groups of animals, as summarized by Needham (1942, pp. 406–407 and 655). The final brown or black melanin of insect eyes is preceded by a red stage, and the same occurs in the shrimp, *Gammarus.* In the last-named case, the embryonic condition is exactly as in the locusts, *Locusta* and *Schistocerca*, *i.e.*, the eyes are at first

* Butler and Innes (1936) showed in *Locusta migratoria migratorioides* (R. and F.) that *gregaria* hoppers and adults have a higher oxygen uptake than *solitaria* ones. *Schistocerca* has, I think, not been studied in this respect.

colourless and later develop the red pigment which, befoie hatching, turns black (brown in locusts). According to Needham, this red pigment of *Gammarus* is probably due to the red intermediate indol product (hallachrome) in melanin deposition.

Adults.—The presence of pink pigments and their nature has been discussed above in the Introduction. They acquire significance when considered in conjunction with reddish pigments occurring in other stages of development.

VI. SOME SOLUBILITY TESTS OF REDDISH PIGMENTS

Some solubility tests which were performed on the reddish pigments of eggs, ovarioles and hoppers gave the following results. Three categories were recognised thus:—(*a*) Readily soluble. Pigment dissolved in the solvent within one hour, giving a distinctly pink- or reddish-coloured solution. (*b*) Weakly soluble. Pigment dissolved very slowly, giving only a faintly pink solution after 24 hours. (*c*) Insoluble. Pigment remained apparently undissolved even after 24 hours, no pink colour being acquirea by the solvent.

Pink pigment of eggs.—Readily soluble in acetone (extremely soluble) and glacial acetic acid. Weakly soluble in 70% ethyl alcohol, absolute alcohol and petrol (?). Insoluble in cold and hot water, 40% formaldehyde, xylol, chloroform, turpentine and glycerine.

Orange-red pigment of ovarioles.—Readily soluble in acetone (extremely soluble), glacial and 50% acetic acid. Weakly soluble in absolute alcohol. Insoluble in water, 40% formaldehyde and glycerine (even after several months). These results also apply to *Hieroglyphus nigrorepletus*.

Pink produced in cuticle of first stage hoppers by chloroform vapour.—Weakly soluble (?) in turpentine and 40% formaldehyde. Insoluble in acetone, glacial acetic acid, absolute alcohol, water and petrol.

These tests suggest a similarity between the pink pigment of eggs and the orange-red pigment of ovarioles. The pink of hoppers produced by chloroform vapour appears to be different.

VII. DISCUSSION AND CONCLUSIONS

The location of the orange-red pigment in the pedicel of the ovarioles would suggest that it is the source from which the pink pigment of the wall of several oviposited eggs is derived. This suggestion receives support from the solubility tests. There is some suggestion (Table I) that the pink of eggs may in some way be connected with the production of black or *gregaria* pattern, though, as already pointed out, the evidence from hatchings is not wholly satisfactory for that view. The presence of reddish pigment in the ovarioles of both *gregaria* and *solitaria* adults also weakens that suggestion.

The pink produced in young hoppers by chloroform vapour evidently marks the black areas of the *gregaria* pattern and thus represents the presumed metabolically active or sensitive areas. The orange-red of the embryonic eyes is the precursor of the dark brown melaninic eye-pigment of hoppers and adults.

The possibility that these reddish pigments play a significant role in phase production and might in some way represent the locustine postulated by Faure (1932) deserves to be kept in mind in future investigations.

VIII. Summary

1. In the desert locust pink pigment is present on the egg-chorion of several oviposited eggs. Usually, all the eggs in an egg-pod are either pink or non-pink. The majority of pink eggs (54%) produced black or *gregaria* hatchings, while the majority of non-pink eggs (58%) produced green or *solitaria* hatchings. Pre-hatching mortality is higher in pink than in non-pink eggs.

2. Orange-red pigment is present in the pedicel of several ovarioles of both 6- and 7-eye-striped *solitaria* and *gregaria* individuals. It is absent in fourth and fifth stage hoppers; probably it develops only with maturity. Testes a.e devoid of the red pigment.

3. Orange-red pigment, similar to that in the desert locust, also occurs in the pedicel of the ovarioles of the rice grasshopper, *Hieroglyphus nigrorepletus* Bolivar.

4. Freshly hatched hoppers develop a pink colour in the cuticle on short exposure to chloroform vapour. *Gregaria* hoppers develop a deeper pink than *solitaria* ones; and further, the pink is more marked in those areas where the black pattern develops. Black hoppers would appear to be more sensitive to chloroform vapour than green ones since, on equal exposure, the latter largely survived while the former did not.

5. The brown eye-pigment of hoppers and adults is preceded in the embryo by an orange-red phase which turns brown before hatching.

6. Solubility tests gave the following results:—(*a*) *Pink pigment of eggs:* Readily soluble in acetone and glacial acetic acid; weakly soluble in 70% ethyl alcohol, absolute alcohol and petrol (?); insoluble in cold and hot water, 40% formaldehyde, xylol, chloroform, turpentine and glycerine. (*b*) *Orange red pigment of ovarioles:* Readily soluble in acetone and 50% and glacial acetic acid; weakly soluble in absolute alcohol; insoluble in water, 40% formaldehyde and glycerine (*c*) *Pink of hoppers produced by chloroform vapour:* Weakly soluble (?) in turpentine and 40% formaldehyde; insoluble in acetone, glacial acetic acid, absolute alcohol, water and petrol.

7. These tests suggest a similarity between the reddish pigments of eggs and ovarioles and their difference from the pink of hoppers. There is a possibility that these reddish pigments play a role in the production of phase differences and might in some way represent the locustine postulated by Faure (1932).

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BIOLOGICAL OBSERVATIONS ON *EMPOASCA KERRI* VAR. *MOTTI* PRUTHI ON POTATO PLANT

By RATTAN LAL, M.SC. (HONS.)

Assistant, Division of Entomology, Indian Agricultural Research Institute, New Delhi

INTRODUCTION

Leafhoppers of the genus *Empoasca* Walsh., comprising over a hundred species and well distributed throughout the world, are all plant feeders and a few of them definitely injurious to cultivated plants. *E. rosae* Linn. and *E. mali* LeB. are pests of apple in the U.S.A. (Ackerman, 1919); *E. libyca* Berg. causes 'coloured rust' in the vineyards of Albania (Ruiz and Mendizabal, 1938); *E. devastans* Dist. is a pest of cotton in India (Husain and Lal, 1940). The potato plant is also attacked by a number of species of *Empoasca*, the important ones being *E. abrupta* DeLong (Poos, 1932), *E. fabae* Harris (Sleesman and Stevenson, 1941), *E. filamenta* DeLong (Manis and Turner, 1942) and *E. solana* DeLong (Carter, 1936). *E. mali* LeB. is the vector of the leaf-roll and mosaic of potato (Hawitt, 1920) and *E. flavescens* Fabr. of crinkle of potato (Elze, 1927). In India the potato plants have been observed to be attacked by *E. kerri* var. *motti* Pruthi (Pruthi, 1940), *E. devastans* Dist. (Husain and Lal, 1940) and *E. punjabensis* Pruthi (Vevai, 1942).

During 1943–44, the present writer made observations on the biology of *Empoasca kerri* var. *motti* Pruthi, occurring in Delhi and on the nature of injury it causes to potato plants. According to Pruthi (*loc. cit.*) it seems to be common in north India, having been collected from linseed (*Linum usitatissimum*), cowpea (*Vigna catjang*), *mung* (*Phaseolus* sp.), castor (*Ricinus communis*) and cotton (*Gossypium* spp.) plants at Lyallpur, from *guara* (*Cyamopsis psoralioides*) and cotton in Sind and from potato (*Solanum tuberosum*) in Delhi.

MATERIAL AND METHOD

Adults of *E. kerri* var. *motti* were collected mostly from the potato fields of the Indian Agricultural Research Institute, New Delhi, during autumn months. The collection of uninjured specimens of these small and active insects necessitated the adoption of a mouth-sucking apparatus after the design of Hills (1933). Early morning appeared to be the most suitable time for collection.

The technique adopted for studying the biology in the laboratory was essentially similar to that given by Fenton and Hartzell (1923), but, instead of large lantern globes, glass cylinders open at both ends were used for rearing the insects. One of the open ends of each such cylinder was covered either by a metal wire-gauze lid (20 meshes to an inch) or by a fine muslin tied with a string and the other end planted round a potted potato plant, reared under insect-proof conditions. Into these cages were liberated a known number of adult insects. Such

cages were further placed in a wire-gauze laboratory to ensure additional protection from other insects.

DESCRIPTION OF DIFFERENT STAGES

Adult.—The adult insect is fully described by Pruthi (*loc. cit.*).

Egg (Plate I, figs. 1 and 2).—Length 0.70 mm., breadth 0.17 mm. Sub-cylindrical, slightly narrowed anteriorly, with a curvature about the middle, somewhat rounded at both ends; translucent, with a pale greenish tinge when freshly laid. A pair of red spots, the eyes of the developing embryo, visible in transmitted light in older eggs.

First instar nymph (Plate I, fig. 3).—Length 0.75 mm., breadth 0.25 mm. General colour transparent white, changing to greenish-yellow after feeding. Head of newly hatched nymph broader than the broadest part of abdomen, but after feeding for some time the latter increases in width even beyond that of head. Eyes oval, very conspicuous, and with a dull reddish-brown tinge. On the head, a pair of hairs situated near the eyes, two pairs on the front margin and two pairs on the face. Rostrum extending up to the metacoxae. Prothorax bare and slightly narrowed in the middle; mesothorax largest of all the thoracic segments; both the meso- and meta-nota bearing a single hair on each of the postero-lateral margins. Meso- and meta-thoracic legs more or less sub-equal, the anterior pair slightly smaller; a few small scattered bristly hairs on the legs. Abdomen apparently 9-segmented; the first and second segments bare, while of the remaining ones each bearing four hairs arranged two on either side, one situated dorso-laterally and the other ventro-laterally; the last segment with a pair of posterior hairs in addition to these.

Second instar nymph (Plate I, fig. 4).—Length 0.95 mm., breadth 0.33 mm. General colour light yellowish-green, abdomen somewhat darker; eyes paler than in the first instar. Structurally similar to first instar nymph with the following differences: Hind margin of meta-thorax sharply concave; rudimentary wing-pads present along the postero-lateral margin of the meso- and meta-nota. Legs progressively longer from the first pair to the third. A pair of hairs on the dorsal side of pro-, meso- and meta-thorax and on the 2nd to the 9th abdominal segments, in addition to those mentioned in the previous instar.

Third instar nymph (Plate I, fig. 5).—Length 1.75 mm., breadth 0.50 mm. General colour yellowish-green, but darker than in the preceding instar; eyes paler, though of the same reddish-brown colour; hairs darker. Head broader than long. Body more robust. Wing-pads more prominent. Third pair of legs distinctly longer than the first two pairs, due to the elongation of tibiae.

Fourth instar nymph (Plate I, fig. 6).—Length 2.0 mm., breadth 0.50 mm. General colour of head and thorax yellowish-green; abdomen green with yellowish-green tip; eyes paler than in the preceding instar. Rostrum reaching up to the bases of second coxae. Wing-pads more prominent, extending to the 4th or 5th abdominal segment; each of the meso-thoracic wing-pads bearing three hairs,

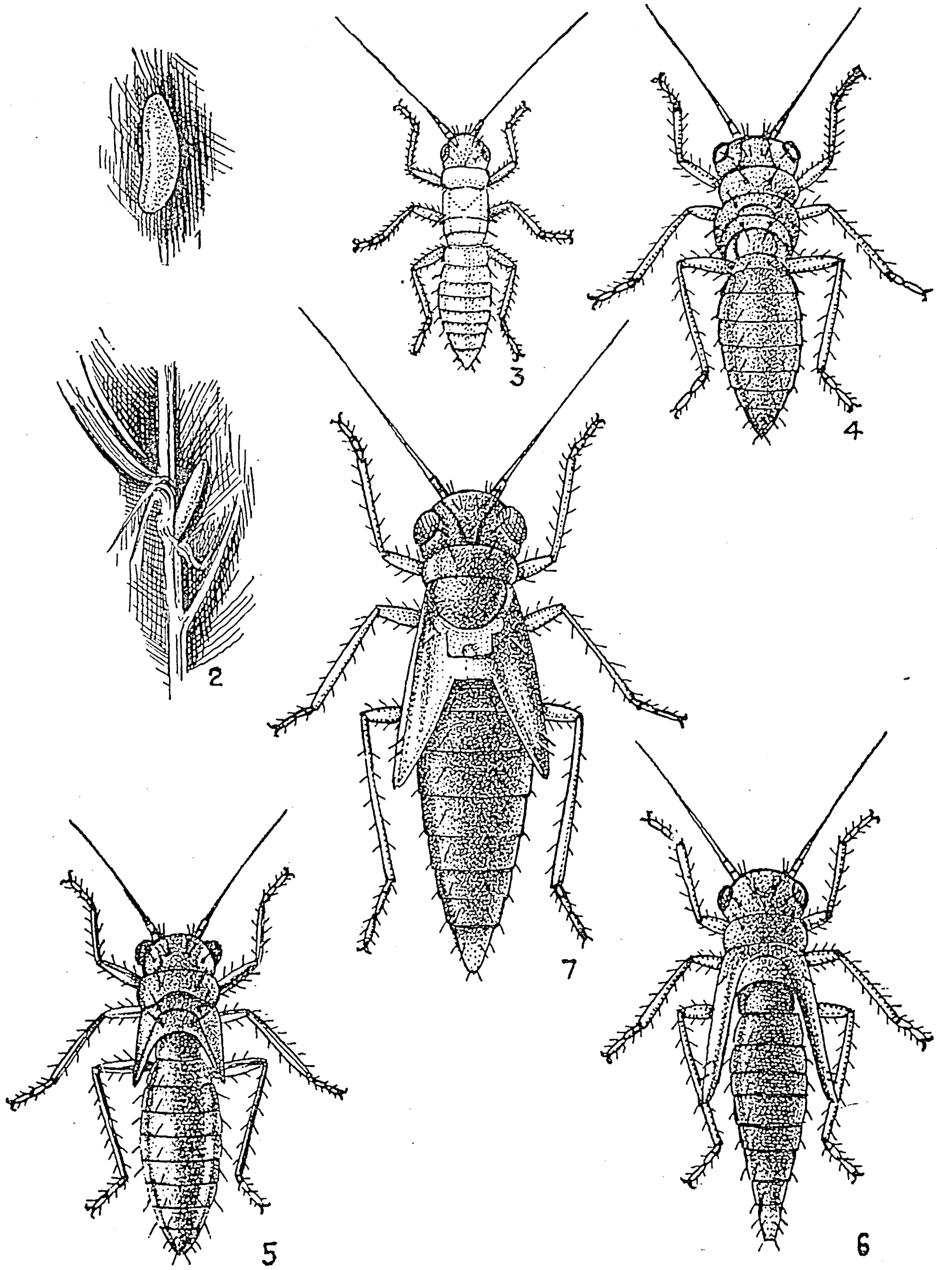

PLATE I

one at the base and the other two just behind the apex; each meta-thoracic wing-pad with a single hair about the middle. Tibiae of the hind pair of legs comparatively long.

"Indian J. Ent., 8"

Fifth instar nymph (Plate I, fig. 7).—Length 2.50 mm., breadth 0.75 mm. General colour darker than in the fourth instar nymph; head and thorax yellowish-green; abdomen green; eyes dull white. Wing-pads thick. Hind pair of legs still more developed, with the tibiae exceptionally long.

LIFE-HISTORY

The males have a much shorter span of life than females. In ten cases, in which the longevity of males was observed, it extended to an average of 14.1 days only, ranging from 1 to 23 days in different individuals. In the case of females it was found to be 36 days from observations on 15 individuals. Some females, however, died within a few days after emergence, but a few lived even up to 94 days.

Usually, the copulation was accomplished during day time, in the later hours of the morning or early in the evening. The study of 12 copulations indicated the actual period of coitus to vary from 15 to 70 minutes. When disturbed during copulation, the individuals try to separate and hop off.

The newly emerged pairs were introduced into cages containing small-sized potato plants which were examined every day for egg-laying. The pre-oviposition period varied from 6 to 16 days, the average being 10.5 days. The oviposition period, on an average, was 25.2 days. In the majority of the cases, a female laid one egg per day, sometimes two and rarely three or four. An examination showed that 70 females laid only one egg, 30 two eggs, 9 three eggs and 4 four eggs per day. Ten dissected gravid females showed not more than four developed ova in the gonads. The total number of eggs, laid by a female, varied from 25 to 60.

The development of 56 individuals from egg to adult was studied in the laboratory from 15th October to 15th December. The observations are recorded in Table I.

TABLE I. *Duration in days of developmental stages in laboratory from 15th October to 15th December*

Stage	Duration in days		
	Max.	Min.	Aver.
Egg ..	11	4	7·5
1st instar nymph ..	4	1	2·5
2nd ,, ,, ..	6	1	3·5
3rd ,, ,, ..	8	2	5·0
4th ,, ,, ..	9	2	5·5
5th ,, ,, ..	13	3	8·0
Total ..	51	13	32·0

The incubation period of eggs extended from 4 to 11 days with an average of 7.5 days. The entire nymphal growth was completed in, on an average, 24.5 days.

The development of 10 individuals was studied separately at 60% relative humidity and at the constant temperatures of 68° F., 86° F. and 95° F., respectively. The results are given in Table II.

TABLE II. *Average duration of developmental stages in days at different constant temperatures*

Stage	Duration at		
	68° F.	86° F.	95° F.
Egg ..	8·1	3·5	Did not hatch
1st instar ..	2·3	1·0	*Nil
2nd „ ..	3·9	1·0	„
3rd „ ..	4·9	2·0	„
4th „ ..	5·4	3·0	„
5th „ ..	8·5	3·0	„
Total ..	33·1	13·5	„

* Development did not take place.

HABITS AND HOST PLANTS

Adults and nymphs of *E. kerri* var. *motti* were usually found resting and sucking juice from the veins and veinlets on the under-surface of the leaves and occasionally from the upper surface as well. Sometimes all the five nimphal stages were completed on a single leaf. *E. kerri* var. *motti* was observed breeding in the fields throughout the year. During the potato season (October to March) all the stages of the insect were common on potato (*Solanum tuberosum*) as well as on some other plants, *viz.*, tobacco (*Nicotiana tabacum*), brinjal (*Solanum melongena*), tomato (*Lycopersicon esculentum*), pea (*Pisum sativum*), cowpea (*Vigna catjang*), linseed (*Linum usitatissimum*) and chilly (*Capsicum annum*). In the absence of these crops, the jassids migrated to castor (*Ricinus communis*), lucerne (*Medicago sativa*) and berseem (*Trifolium alexandrinum*), and passed the rest of the spring and the summer on these plants. Their numbers, however, decreased as the season advanced. From September onwards they again reappeared on the host plants mentioned above.

NATURE OF INJURY AND EXTENT OF DAMAGE TO POTATO FOLIAGE

Fenton and Hartzell (*loc. cit.*) and Vevai (*loc. cit.*) described the course of injury to potato foliage by *Empoasca mali* LeB. and *E. punjabensis* Pruthi, respectively. The present observations on the injury caused by *E. kerri* var. *motti* to potato plants agree with those made by these workers. The tip of a leaflet on which the leafhoppers fed became brown, turned upwards and died (Plate II, fig. 1 *a*, *b*). Similar brown spots also appeared on the margin. These areas coalesced, until the entire margin was brown and more or less rolled up. The diseased condition spread from the tip and margin to the mid-rib of the leaflet (Plate II, fig. 2, *c*, *d*) and

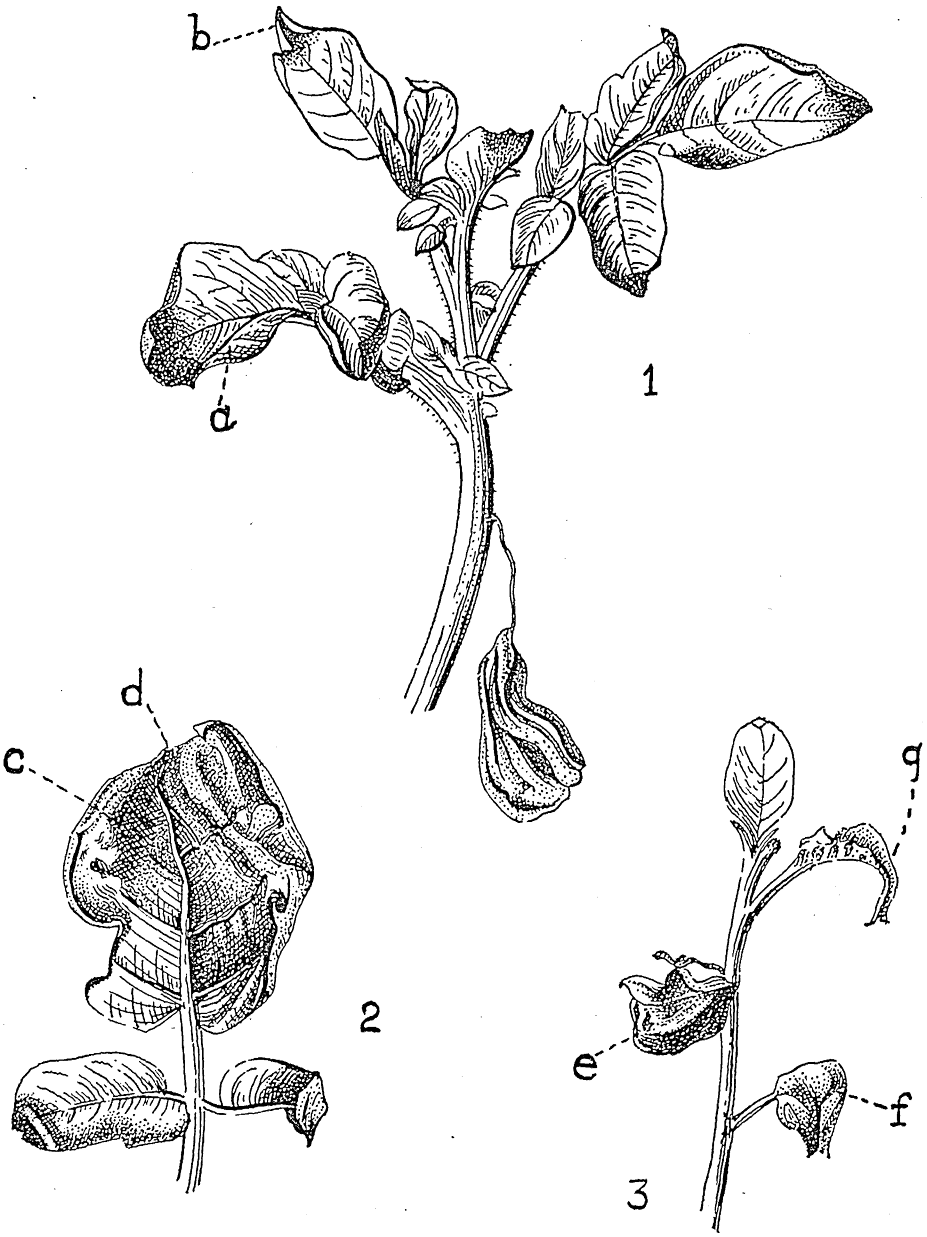

PLATE II

proceeded slowly towards the basal area which sometimes remained green for a considerable time. In bad cases, the entire portion of the leaf around the mid-rib and even the basal area became brown, resulting in the drying of the entire leaflet (Plate II, fig. 3, *e*, *f*, *g*).

ACKNOWLEDGEMENTS

The writer is much indebted to Dr. H. S. Pruthi, formerly Imperial Entomologist, Imperial Agricultural Research Institute, New Delhi, who suggested this problem and provided laboratory facilities. Thanks are also due to Mr. C. K. Samuel and Dr. Ramdas Menon for kindly going through the manuscript and offering relevant criticisms, and to Mr. P. Narayanan, Artist, and his colleagues for making the drawings reproduced in this paper.

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EXPLANATION OF PLATES

PLATE I. Stages of *Empoasca kerri* var. *motti* Pruthi.

- FIG. 1. A freshly laid egg, extracted from leaf-tissue. ×42.
- FIG. 2. Partially inserted egg *in situ* in the mid-rib of a potato leaflet.
- FIG. 3. First Instar nymph. × 42.
- FIG. 4. Second Instar nymph. × 42.
- FIG. 5. Third Instar nymph. × 24.
- FIG. 6. Fourth Instar nymph. × 24.
- FIG. 7. Fifth Instar nymph. × 24.

PLATE II. Different stages of hopper-burn caused by *E. kerri* var. *motti* on Potato plant.

FIG. 1. A twig showing various stages of hopper-burn on leaflets.
(*a*) A leaflet with margins turned upwards.
(*b*) A leaflet with its tip overturned.

FIG. 2. A part of leaf showing advanced stage of hopper-burn.
(*c*) Mid-rib of a hopper-burnt leaflet partly in green state.
(*d*) A leaflet with tip and margin dried up due to hopper-burn.

FIG. 3. A twig showing three leaflets (*e*, *f*, *g*) completely dried up as a result of hopper-burn.

Note.—(In all the cases the hopper-burnt leaflets show different shades of brown colour along with rolling up of their margins.)

INSECT FAUNA OF AFGHANISTAN—IV. LEPIDOPTERA

By DR. TASKHIR AHMAD, PH.D. (CANTAB.)
Indian Agricultural Research Institute, New Delhi

In this contribution, the fourth of the series presenting the insect fauna of Afghanistan, the Lepidopterous insects collected by the writer during a tour of that country as a member of the Indian Agricultural Delegation in 1939 are listed. This material comprises thirty species belonging to fifteen different families. Identification of these insects has been made chiefly with the help of the Imperial Pusa Collection in the Laboratory of the Imperial Entomologist at New Delhi, and partly through the courtesy of the Forest Entomologist, Forest Research Institute, Dehra Dun and the Imperial Institute of Entomology, London, whose willing co-operation is gratefully acknowledged.

As a member of an agricultural delegation more attention was paid by the writer to the distribution and economic status of the insect pests of crop plants. Though many Lepidoptera have been recorded from this country by previous visitors, little attention seems to have been paid to this aspect of Afghan Entomology. It is worthy of mention that some notorious insect pests such as *Hyponomeuta padella* (Linn.) and *Cydia pomonella* (Linn.) on apple, plum and other fruit trees and *Lithocolletis populi* Filip. on poplar are widely distributed in Afghanistan. Some other important pests, like *Plutella maculipennis* (Curt.) and *Pieris brassicae* (Linn.) on cabbage, *Spilonota ocellana* D. & S. on apple and *Laphygma exigua* Hubn. on berseem have been observed to have a localised distribution. Besides these, *Euproctis signata* Blanch. has been noticed as a serious pest of several fruit trees like apples, plums, apricots, etc., at Ghazni.

The earliest collections of Lepidopterous insects, from Afghanistan, seem to have been made by Major Howland Roberts from Rokeran, a village about 6 miles off Kandahar. Roberts collected twenty-nine species, mostly of butterflies, and made sketches of the immature stages of some of these. Butler (1880) who identified this collection published a list together with the sketches made by Roberts. Soon afterwards, Butler (1882) published another paper based on collections received from Col. Swinhoe who was working as administrative head of the Commissariat in South Afghanistan during 1880–81. Herein he listed twenty-nine species from this country besides others from the neighbouring regions of India. Col. Swinhoe himself (1885) later published another paper in which he included all the Lepidopterous insects so far known from Afghanistan. Dr. T. E. T. Aitchison, who visited this country as Naturalist attached to the Afghan Delimitation Commission and made extensive collections of insects could not procure any Lepidopterous insects. In his report (1885) on the Zoology of Afghanistan he says:

"I made no collection of Butterflies (though a few were seen), owing to my not being able to engage collectors. These only appeared in small numbers of the same species here and there when there was perfect stillness in the air. This stillness occurs so infrequently and at such irregular intervals that it would have required the entire devotion of one's time to collecting these insects alone. When the wind rose they were driven about like so many leaves, and seemed with difficulty to gain shelter. I never, to my knowledge, saw a perfect specimen, all were battered (one may say) to pieces, their wings becoming deeply irregularly fringed from continuous fractures and injuries."

Hampson in his series of the fauna of British India, Moths (1892–1896) and his revision of the Pyraustinae has mentioned some Indian species having their distribution extending to Afghanistan. Likewise Bingham (1905–1907) in his Indian Fauna of Butterflies has referred to thirteen Indian species known also from this country. Most of these are mere repetition of the previous records of Butler and Swinhoe. Zerny (1914) in his Palearctic Pyralidae present in the "K.K. natural—historischen Hoffmuseum" at Vienna has mentioned four species from "Kuschk" (Hindu Kush ?), North Afghanistan. These appear to have been collected by Bang-Hass. Bell and Scott (1937) in their work on the Indian Sphingidae have recorded three of the Indian forms as having their distribution in Afghanistan probably from the records made by Butler and Swinhoe. Janjua (1938) reported the presence of *Cydia pomonella* (Linn.) in Ghazni, Kabul and Kandahar. Talbot (1939) in the second edition of the Indian fauna of Butterflies has mentioned the occurrence of *Paranassius delphius kafir* Avinoff from Safed Koh in Afghanistan to Kafiristan.

This seems to be the all information available to the writer on species of Lepidoptera hitherto recorded from Afghanistan. The names under which these insects have appeared in the above mentioned records have in many cases undergone changes, so much so that it may be difficult for a collector to say whether the insects noticed by him are new records for the country or not. Therefore an index to the species recorded from Afghanistan with their more up-to-date names and synonyms is appended (*vide* Appendix A).

Just before leaving Afghanistan, the writer had the opportunity of examining a collection of insects made by Mr. Hide Into of the Agricultural College, Tokyo, who at that time was teaching Entomology in the School of Agriculture at Kabul. This contained eleven species of Lepidopterous pests, belonging to five families without any locality labels. As some of them such as *Illeberis pruni* (Dyer), *Naranga aenescens* Moore, *Chilo simplex* Butler, etc., are so far known only from the Far East it is likely that Into's entire collection was not locally made. However since some species from his collection, like *Euxoa segitum* (Schiff.) and *Pieris rapae* are already recorded from Afghanistan I have deemed it fit to append a full list of the insects noticed in his collection together with some notes (*vide* Appendix B).

SYSTEMATIC LIST OF THE SPECIES OF LEPIDOPTERA COLLECTED BY THE WRITER FROM AFGHANISTAN

Hyponomeutidae	.. 1.	*Hyponomeuta padella* Linn.
Lithocolletidae	.. 2.	*Lithocolletis populi* Filip.
Plutellidae	.. 3.	*Plutella maculipennis* (Curt.)
Eucosmidae	.. 4.	*Cydia pomonella* Linn.
	5.	*Spilonota ocellana* D. & S.
Tortricidae	.. 6.	*Cacoecia pomivora* Meyr.
Pyralidae	.. 7.	*Epicrocis aegnusalis* Wlk.
	8.	*Euzophera punicella* Moore.
	9.	*Noctuella floralis* Hubn.
	10.	*Nomophila noctuella* Schiff.
	11.	*Ommatopteryx ocellea* (Haw.)
Nymphalidae	.. 12.	*Vanessa cardui* (Linn.)
Satyridae	.. 13.	*Coenonympha pamphilus* Linn.
	14.	*Eumenis parisatis parsis* Le Cherf.
Lycaenidae	.. 15.	*Lycaena phlaeas stygianus* Butler.
	16.	*Polyommatus icarus fugitiva* Butler.
Pieridae	.. 17.	*Colias hyale erate* Esp.
	18.	*Pieris rapae* Linn.
	19.	*Pontia daplidice moorei* Rob.
Hesperiidae	.. 20.	*Carcharodus alceae swinhoei* Watson.
Geometridae	.. 21.	*Rhodometra sacraria* Linn.
Arctiidae	.. 22.	*Utetheisa pulchella* Linn.
Noctuidae	.. 23.	*Agrotis* sp.
	24.	*Apopestes spectrum* (Esp.)
	25.	*Catocalla afghana* Swinh.
	26.	*Laphygma exigua* Hubn.
	27.	*Plusia ni* Hubn.
	28.	*Sarothripus revayana* Scop.
Lymantriadae	.. 29.	*Euproctis signata* Blanch.
	30.	*Lymantria obfuscata* Wlk.

HYPONOMEUTIDAE

1. **Hyponomeuta padella** Linn.

Linne, *Systemma Naturae*, 10th ed., p. 535 (1758)

This species was found as a pest of various fruit trees at Paghman near Kabul on 24th June, Chardeh on 4th July, Tashqurghan on 11th July and Ghazni on 18th July. Larvae were found defoliating apple, plum, apricot, almond, willow and several other deciduous fruit trees by webbing the leaves together and feeding inside. Cherry was attacked to a less extent. Mostly larval and pupal stages were present and the damage was extremely serious. At Chardeh over 100 almond trees had been completely killed by this pest. About

2% of the full grown larvae and pupae were found attacked by the maggots of a fly. At Ghazni (18th July) the defoliator was present in a less serious form. I have 49 specimens of this species in my collection.

A high percentage of full grown larvae and pupae was found parasitised by *Pteromalus puparium* and some species of *Monodontomerus* and *Pleurotropis.* From parasitised pupae collected on 17th July, a large number of parasites emerged on 20th July.

This species is widely distributed throughout England, Europe, Russia, and parts of U.S.A. as a pest of apple, apricot, plums, hawthorn and other fruit trees. It was recorded from India (Baluchistan) for the first time in 1941.

LITHOCOLLETIDAE

2. **Lithocolletis populi** Filip.

Filipjev, N. N., 1927, *Rev. russe Ent.*, **20** (3–4): 289; *Iris*, Dresden, **45** (2): 70–73

This leaf-miner was found as an important pest of poplar all over Afghanistan. I have 25 moths before me, reared from larvae collected from Kabul on 30th June; Aibak on 13th July and Paghman on 17th July. Some of the larvae collected on 30th June pupated on 5th July and emerged as moths on 14th July, the pupal period being thus about 9 days. Likewise, from larvae and pupae collected on 17th July, over a dozen moths emerged on 25th July and two on 7th August; from pupae collected on 13th July two moths emerged on 16th and two on 20th July. The larval mines were more abundant on the under surface of the leaves. The damage was so serious that a single leaf showed 30–40 larval and pupal chambers.

The pest is previously recorded on poplar from Russian Turkistan.

This species was originally named *L. populiella* by Filipjev (1927); but later finding that the specific name is already preoccupied, he renamed it *L. populi* Filip. The North American *L. populiella* Cramb (1878, *Bull. U.S. Geol. Survey*, **4**: 101) is thus quite different from this species.

PLUTELLIDAE

3. **Plutella maculipennis** (Curt.)

Curtis, *British Entomology*, **9**: 2 (1832)

A large number of caterpillars feeding on young shoots and tender leaves of cabbage and leaves of carrot near Kabul were collected on 2nd July and kept under observation. Five of these pupated on 5th July and six on 8th July. Four moths of this species emerged on 7th July and five on 10th July, after a pupal period of only 2 days. Several adults were also netted from a potato field.

This cosmopolitan species occurs wherever cabbage and cruciferous plants are grown in the world.

EUCOSMIDAE

4. **Cydia pomonella** Linn.

Linne, *Systemma Naturae*, 10th ed., p. 538 (1758)

This notorious pest of apples and other fruits was found in different stages of development at a number of localities in Afghanistan. Larvae boring apple fruits were collected from Kabul on 26th and 28th June and again on 16th July. At Kandahar, larvae infesting plum, apple and Bihi fruits and pupating under the bark of apricot trees were collected between 22nd and 24th July. The pest was also found infesting apples at Government Garden, Istalif on 26th June and Ghazni on 18th July. At Istalif over 75% of the fruits were found infested, some of them containing 2–3 larvae.

Some of the larvae collected at Kabul on 26th June pupated during the week following 2nd July. From these pupae, one moth emerged on 11th, two on 20th and one on 26th July after a pupal period of 2–3 weeks. Another lot of larvae collected at Kabul on 28th June, pupated on 8th July. Of these, two moths emerged on 28th July and two on 9th August. From pupae collected on 16th July at Kabul one moth emerged on 16th and another on 20th July. At Kandahar almost full grown larvae collected on 22nd and 23rd July emerged as moths on the following dates of August: one on 8th, two on 10th, three on 15th, three on 16th, two on 17th, one on 19th, four on 22nd, two on 24th and one on 25th. A Tachinid fly emerged from one of the parasitised caterpillars on the 17th August.

The codling moth is well known to apple growers all over the world. It is a serious pest in Europe, Canada, U.S.A., South America, South Africa, Australia, New Zealand, etc. In India it was first recorded in 1935 and is now well established in Baluchistan and the North-West Frontier Province. From its status and distribution in Afghanistan it is obvious that in the absence of quarantine laws on the land-frontier of India, it gained entry into North-West India from Afghanistan. In one case a consignment of apple fruits on its way to Peshawar from Kabul was found by the writer, badly infested with codling moth larvae.

5. **Spilonota ocellana** D. & S.

A larva feeding on apple leaves at Paghman on 17th July pupated later and a moth of this species emerged.

This species has a very wide distribution throughout Europe, U.S.A., North Africa and Baluchistan (India).

TORTRICIDAE

6. **Cacoecia pomivora** Meyr.

Meyrick, *Exotic Microlepidoptera*, **2**: 340

A number of caterpillars feeding on rose leaves were collected near Kabul on 28th July. Two of these pupated on 31st July 1939 and emerged as moths on 8th August, *i.e.*, after 8 days of pupal period.

This is a common species in India, its larvae are reported boring apple fruits in Kumaon Hills and feeding on apple leaves in Baluchistan thus doing sometimes fairly serious damage.

PYRALIDAE

7. Epicrocis aegnusalis Wlk.

Walker, *Catalogue of the Lepidoptera Heterocera in the Br. Museum*, **19**: 905 (1859)

I have two moths of this species before me caught at light from Kandahar on 21st and 25th July. It is previously recorded from Madagascar, China, India, Ceylon, Burma and Australia

8. Euzophera punicella (Moore)

Moore, *Indian Museum Notes*, **2**: 28 (1893)

Brinjal leaves were found folded and damaged by larvae of this species at Dakka on 22nd June. Some larvae found boiing fruits of 'Bihi' and plums along with those of *Cydia pomonella* Linn. at Kandahar on 22nd July were collected and kept in a cage. From this material, two moths of *Euzophera punicella* emerged on 17th August, one on 19th and four on 22nd August.

It is previously known as a major pest of apple and pomegranate in Baluchistan (India).

9. Noctuella floralis Hübn.

Hubner, *Sammlung Europaischr Schmetterlinge, Pyralid*, fig. 142

I have seven moths of this species caught at light, two from Doab-i-Mekhzarin on 14th July and five from Kandahar on 25th July.

This is a widely distributed species previously known from Afghanistan, Europe, Central Asia and North-West India.

10. Nomophila noctuella Schiff.

Schiffermiiller, *Systematische Verzeichniss d. Schmetterlinge d. Wiener Gegeud*, p. 136 (1776)

This species was found to be widely distributed in Afghanistan. I have number of specimens taken at light from Darra-i-Khaibar on 22nd June, Doab-i-Mekhzarin on 14th July, Ghazni on 19th July, Kandahar on 21st and 23rd July, and Kabul on 31st July.

This is a cosmopolitan species. It is a pest of lucerne in Cyrenaica. What has been listed from Kandahar as *Stenopteryx hybridalis* by Butler (1882) and Swinhoe (1885) is but this species.

11. Ommatopteryx ocellea (Haw.)

Haworth, *Lepidoptera Britanica*, London, p. 486 (1903)

Two specimens taken at light from Doab-i-Mekhzarin on 14th July and Kandahar on 21st July are in my collection.

The species is previously recorded from Afghanistan, Europe and different parts of India (Punjab, Karachi, Poona, etc.).

NYMPHALIDAE

12. **Vanessa cardui** (Linn.)

Linne, *Systemma Naturae*, 10th ed., p. 475 (1758)

A number of larvae feeding on hollyhock leaves were collected from Paghman on 24th June and British Legation Garden, Kabul, on 28th June. One of these pupated on 27th June and five more pupated upto 3rd July. Out of these, one adult emerged on 6th, one on 7th, two on 9th, one on 10th and one on 13th July. Thus under these conditions, the pupal period was about 9–10 days. A few adults were also collected on wing near Darra-i-Khaiber on 22nd June.

This species is distributed all over the world, with a great variety of food plants. It has already been recorded from Afghanistan by Butler (1880, 1882) and Swinhoe (1885).

SATYRIDAE

13. **Coenonympha pamphilus** Linn.

Linne, *Systemma Naturae*, 10th ed., p. 472 (1758)

There are four adults collected on wings at Paghman on 29th June. The species is previously known to be distributed from North and Central Europe to interior Asia, Turkistan, Ferghana and Persia.

14. **Eumenis parisatis parsis** Le Cherf.

Le Cherf, *Ann. Hist. Nat.*, Paris, **2**: 39, t_2, fig. 13 (1913)

There are 8 specimens in my collection caught on wings at Darra-i-Khaibar on 22nd June. They had rather dull colouration very much resembling the colour of the rocky environment and therefore while sitting on some of the stones they could not be easily located.

This has already been recorded by Butler (1880) under the name *Hipparchia parisatis* from collections made by Major Roberts.

LYCAENIDAE

15. **Lycaena phlaeas stygianus** Butler

Butler, *Proc. Zool. Soc.*, London, p. 408 (1880) (*Chrysoplames stygianus*)

There are two specimens before me taken on wings; one from Kabul on 25th June and another from Kandahar on 22nd July.

This is previously recorded from Afghanistan (Kandahar), North-West Europe and India (Western Himalayas, Kashmir, Nainital, Kumaon, Mussoorie, Simla, Quetta, etc.). This was first recorded from Afghanistan under the name *Chrysophanus stygianus* by Butler (1880, 1882) and Swinhoe (1885).

16. **Polymmatus icarus fugitiva** But.

Butler, *Proc. Zool. Soc.*, London, p. 606 (1881)

There are eight specimens of this species in my collection taken on wings, five from Khanabad on 7th July and three from Paghman on 29th July.

It is previously recorded from Baluchistan. From Afghanistan this has been recorded by Butler (1880, 1882) and Swinhoe (1885) under the name *Lycaena persica.*

PIERIDAE

17. Colias hyale erate Esp.

Esper, *Ausl. Schnutt.*, 1: (2), pl. 119, fig. 3 (1806?) (*Papileo erate*)

Two butterflies of this species were captured on wings at Paghman on 29th July. It is known to occur in Baluchistan, N.W.F. Province, North-Western Himalayas and from Chitral to Kumaon. *Colias hyale* L. is common in France and South Russia as a pest of clover and lucerne. Butler (1880, 1882) and Swinhoe (1885) have recorded this from Afghanistan under the name *Colias erate.*

18. Pieris rapae Linn.

Linne, *Systemma Naturae*, 10th ed., p. 468 (1758)

Three specimens collected from Kabul on 28th June and 2nd July and one from Paghman on 30th June are in my collection. These were taken on wings from cabbage field.

Specimens of this species have also been observed in the collection of Mr. Hide Into at Kabul. This has been recorded from Afghanistan by Swinhoe (1885) under the name *Ganoris rapae.*

19. Pontia deplidice moorei Rob.

Roberts, in Seitz's '*Macrolepidoptera*', *Fauna Palaearctica*, 1: 49 (1907)

I have four specimens before me, caught on wings, one from Paghman on 30th June, one from Kabul on 2nd July and two from Mazar-i-Sharif on 10th July.

The species is widely distributed throughout Europe, Asia Minor, Russia, Persia, North-West India and Afghanistan. The variety *moorei* is recorded from North-West India (Peshawar, Baluchistan, Chitral, Murree, etc.). This has been recorded from Afghanistan by Butler (1880) and Swinhoe (1885) under the name *Synchloe daplidice.*

HESPERIIDAE

20. Carcharodus alceae swinhoei Watson

Watson, *Proc. Zool. Soc.*, London, p. 68 (1893)

Caterpillars of this species were collected feeding on hollyhock leaves at Paghman on 24th June and again in British Legation Garden, Kabul, on 28th June. Two of the former lot pupated on 3rd July and emerged as adults on 11th July. From the second lot, one pupated on 28th June and five pupated on different dates between 28th June and 3rd July. From these, one adult emerged on 6th July, one on 7th July, two on 9th July, one on 10th July and one on 13th July. These observations show that the pupal period is 8–10 days during July under Kabul conditions.

One butterfly was also caught on wings from Tashqurghan on 13th July.

This species is previously recorded from Kashmir, Chitral, North-West Himalayas, Baluchistan (Quetta) and Afghanistan (Kandahar).

GEOMETRIDAE

21. **Rhodometra sacraria** Linn.

Linne, *Systemma Naturae*, i, **2**: 863 (1766)

There are five specimens in the collection taken at light; two from Doab-i-Mekhzarin on 14th July and three from Kandahar between 21st and 25th July.

It is previously recorded from Canary Islands, St. Helena, Africa, South Europe, West Asia and East Turkistan. This seems to be identical with *Sterra sacraria* recorded by Butler (1882) and Swinhoe (1885).

ARCTIIDAE

22. **Utetheisa pulchella** Linn.

Linne, *Systemma Naturae*, 1, **2**: 884 (1766)

Two specimens taken at light from Ghazni on 20th July and Kandahar on 25th July are in the collection before me.

This is a common species occurring throughout India, Ceylon, Java, West Australia, China, Indo China, etc. Under the name *Deiopeia pulchella* this has been recorded from Afghanistan by Butler (1880, 1882) and Swinhoe (1885).

NOCTUIDAE

23. **Agrotis** sp.

Agrotis: Ochsenheimer, *Die Schmetterlinge von Europa*, **4**: 66 (1816)

Several moths of *Agrotis* sp., not identified so far, were collected from Bamian on 4th July, from Aibak on 5th July (at light), from Baghlan on 6th July and from a vineyard at Kandahar on 25th July.

24. **Apopestes spectrum** (Esp.)

Esper, *Die Europaische Schmetterlinge*, **4**, 1: 131, pl. 100, figs. 3, 4

There are three specimens of this species in the collection, captured at light from Paghman on 29th June, Mazar-i-Shari on 10th July and Doab-i-Mekhzarin on 14th July.

The species is known to occur in India (Quetta, Murree, Dharmsala, Mainpuri, etc.), Europe, Syria, Asia Minor, Armenia and Turkistan. In Russia, its eggs are recorded as host for *Trichogramma semblides*. This is the same as *Apopestes phantasma* listed by Butler in 1880.

25. **Catocalla afghana** Swinh.

Swinhoe, *Trans. ent. Soc.*, London, p. 352 (1885)

There are four adults of this species in the collection. Two were caught at light at Ghazni on 19th July, one caught on wings at Kandahar on 22nd July and another at Kabul on 30th July.

The species is previously recorded from Kashmir, Rajaori and Baluchistan.

26. **Laphygma exigua** Hübn.

Hubner, *Sammlung Europaischr Schmetterlinge Noct.*, fig. 362 (1802)

There are four specimens before me taken at light from Doab-i-Mekhzarin on 14th July, Ghazni on 19th July, and from Kandahar on 21st July. Some larvae were found cutting holes in berseem leaves at Bamian on 5th July.

It occurs throughout India, Egypt, etc., as a well-known pest of great variety of fodder and vegetable crops.

27. **Plusia ni** Hübn.

Hubner, *Sammlung Europaischr Schmetterlinge, Noct.*, fig. 284 (1802)

I have only one specimen taken at light from Kandahar on 21st July.

It is previously recorded from Jamaica, Cuba, Formosa, etc. In Formosa, the larvae are reported to damage poppy plants.

28. **Sarothripa revayana** Scop.

Scopoli, *Ann. Mag. Nat. Hist.*, 5: 116

Some larvae feeding on young poplar shoots were collected from Paghman on 29th July. Eight of these pupated on 31st July and seven moths emerged on 8th August and one on 9th August after a pupal period of 8–9 days.

This is previously recorded as a pest of poplar in Russia.

LYMANTRIIDAE

29. **Euproctis signata** Blanch.

Blanchard, *Ins. Voyage Inde Jacquimont*, **4**: 24, t. **1**, fig 7 (1844) (Liparis)

This hairy caterpillar was found as a serious pest at Ghazni on 18th July. A large number of moths were collected at light from this locality on the 19th July. The caterpillars were defoliating apple, apricot, plum and almost all other deciduous fruit trees excepting mulberry, with the result that these trees had not borne any fruit during the last two years. The pest was said to have come into prominence after the severe winter of 1937–38 when probably its parasites got killed. At the time of our visit large number of caterpillars and pupae were found parasitised by *Monodontomerus aereus* and *Entedon* sp. Adults of both these parasites were seen in large numbers in the infested orchards. Out of the parasitised material collected on the 19th, three chalcids emerged on 22nd and

three on 23rd July. From two egg clusters of *Euproctis signata* collected on 18th July, about 500 and 36 larvae hatched out on 24th and 30th July respectively.

This is previously known from India (Himalaya).

30. Lymantria obfuscata Wlk.

Walker, *Catalogue of the Lepidoptera Heterocera of the Br. Museum*, **32**: 367 (1865).

One specimen taken at light from Ghazni on 19th July and four bred from larvae found feeding on fig leaves at Kandahar on 25th July are in the collection before me. The larvae pupated on 27th July and emerged as moths on 7th August. From parasitised larvae collected on 25th July, three cocoons of *Apanteles* sp. were found on 31st July and the adult parasites emerged on 8th August. The pupal period of the parasite was thus about 8 days.

This is previously known from North-West India (Kashmir, Punjab) and Singapore.

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APPENDIX A

INDEX TO THE LEPIDOPTERA RECORDED FROM AFGHANISTAN BY PREVIOUS WORKERS

In this index the species, sub-species and varieties are separately listed for the sake of ready reference. Numbering, however, is restricted to species which are considered distinct. Species marked (*) are not so far recorded from India.

1. *adaptella* (Walker), *Lomonia* (Pyralidae):

    = *Acrobasis imbella:* Butler [1882, *Ann. Nat. Hist.*, (5) **9**: 211]; Swinhoe (1885, *Trans. Ent. Soc., London*, p. 354) from Kandahar.

    = *Lamina anella:* Hampson (1896, Fauna Br. India, Moths, **4**: 7).

2. *afghana* Moore, *Zygaena* (Zygaenidae):

    Hampson (1892, Fauna Br. India, Moths, **1**: 231).

3. *alecto alecto* (Linnaeus), *Thereta* (Sphingidae):

    = *Chaerochampa cretica:* Butler (1880, *Proc. Zool. Soc.*, pp. 411–12) from Rokeran; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 346) from Kandahar.

    = *Chaerochampa alecto:* Hampson (1892, Fauna Br. India, Moths, **1**: 85).

    Synonymy: Talbot (1939, Fauna Br. India, Moths, **5**: 440–41).

4. *alchymillae dravira* (Moore), *Carcharodus* (Hesperiidae):

    = *Eurynnes dravira:* Butler [1882, *Ann. Nat. Hist.*, (5) **9**: 210]; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 346) from Kandahar.

    Synonymy: Peile (1937, Guide Coll. Butterfly India, p. 227).

5. *anella:* (see adaptella).

6. *armigera* (Hubner), *Heliothis* (Noctuidae):

    Butler [1882, *Ann. Nat. Hist.*, (5) **9**: 210]; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 347) from Kandahar.

*7. *aurata* Scopoli, *Pyrausta* (Pyralidae):

    Hampson (1899, *Revis. Pyraust.*, p. 267).

8. *aurota aurota* (Fabricius), *Anaphis* (Pieridae):

    = *Belenois mesentina:* Butler (1880, *Proc. Zool. Soc.*, p. 409) from Rokeran; Butler [1882, *Ann. Nat. Hist.*, (5) **9**: 209] from Kandahar.

    = *Pieris mesentina:* Swinhoe (1885, *Trans. Ent. Soc.*, p. 342) from Kandahar.

    Synonymy: Talbot (1939, Fauna Br. India, Butterflies, 2nd ed., **1**: 380.

aversa (see *segetum*).

9. *boeticus* Rambur, *Carcharodus* (Hesperiidae):

= *Erynnis marrubi:* Butler (1880, *Proc. Zool. Soc.*, London, p. 411) from Kandahar; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 345).

Synonymy: Evans (1932, Ident. Ind. Butterfly, p. 352).

10. *boeticus* (Linnaeus), *Lampides* (Lycaenidae):

= *Polyommatus boeticus:* Butler (1880, *Proc. Zool. Soc.*, p. 406) from Rokeran; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 341) from Kandahar.

Synonymy: Evans (1932, Ident. Ind. Butterfly, p. 236).

bracteata: (see *cristophi*)

11. *cardui* (Linnaeus), *Vanessa* (Nymphalidae):

= *Pyrameis cardui:* Butler (1880, *Proc. Zool. Soc.*, p. 406) from Rokeran; Butler [1882, *Ann. Nat. Hist.*, (5) **9**: 207]; Swinhoe (1885, *Trans. Ent. Soc. London*, p. 339) from Kandahar.

Synonymy: Evans (1932, Ident. Ind. Butterfly, p. 177).

cashmirensis (see *vicrama*)

centralis (see *lupinus*)

12. *cespitalis* (Schiff.), *Pyrausta* (Pyralidae):

= *Herbula cespitalis:* Butler [1882, *Ann. Mag. Nat. Hist.*, (5) **9**: 210] from Kandahar.

synonymy: Hampson (1899, *Rev. Pyraust.*, p. 252).

chamanica (see *loewii*)

13. *chryssipus* (Linnaeus), *Danais* (Danaidae): Butler (1880, *Proc. Zool. Soc.*, p. 405) from Rokeran.

= *Limnas chrysippus:* Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 337) from Kandahar; Bingham (1905, Fauna Br. India, Butterfly, **1**: 11–13).

14. *circumflexa* (Linnaeus), *Syngrapha* (Noctuidae):

= *Plusia circumflexa:* Butler [1882, *Ann. Nat. Hist.*, (5) **9**: 210]; Swinhoe (1885, *Trans. Ent. Soc., London*, p. 350) from Kandahar.

15. *consimilis* Warr, *Larentia* (Geometridae):

Hampson (1895, Fauna Br. India, Moths, **3**: 380).

16. *contracta contracta* Butler, *Euchrysops* (Lycaenidae):

= *Lampides contracta:* Butler (1880, *Proc. Zool. Soc.*, p. 406) from Rokeran.

= *Catochrysopa contracta:* Swinhoe (1885, *Trans. ent. Soc., London* p. 341) from Kandahar.

Synonymy: Evans (1932, Ident. Ind. Butterfly, p. 235).

cretica (see *alecto*).

17. *cristophi bracteata* (Butler), *Polyommatus* (Lycaenidae):

= *Lycaena bracteata* Butler (1880, *Proc. Zool. Soc.*, p. 407) from Rokeran; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 340) from Kandahar.

Synonymy: Evans (1932, Ident. Ind. Butterfly, p. 226).

18. *daplidice* (Linnaeus), *Pontia* (Pieridae):

= *Synchloe daplidice:* Butler (1880, *Proc. Zool. Soc.*, p. 410) from Rokeran Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 342) from Kandahar.

= *Pieris daplidice:* Bingham (1907, Fauna Br. India, Butterfly, **2**: 175).

Synonymy: Peile (1937, Guide Coll. Butterfly, *India*, p. 44).

19. *davendra davendra* Moore, *Maniola* (Satyridae):

= *Epinephale roxane:* Butler (1880, *Proc. Zool. Soc.*, p. 405) from Rokeran Butler [1882, *Ann. Mag. Nat. Hist.*, (5) **9**: 207].

= *Epinephale davendra* var. *roxane:* Swinhoe (1885, *Trans. Ent. Soc. London*, p. 338) from Kandahar.

Synonymy: Evans (1932, Ident. Ind. Butterfly, p. 112).

20. *delphius kafir* Avi-noff, *Parnassius* (Papilionidae):

Talbot (1939, Fauna Br. India, Butterfly, 2nd Ed., **1**: 278–79) from Safed Koh.

didyma (see *trivia*).

*21. *disparalis* (Herr.-Schiff.), *Tegostoma* (Pyralidae):

Hampson (1899, *Revis. Pyralid.*, p. 277).

= *Aesheremon disparalis:* Butler [1882, *Ann. Nat. Hist.*, (5) **9**: 211]; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 353) from Kandahar; Hampson (1896, Fauna Br. India, Moths, 4: 447).

dravira (see *alchymillae*).

22. *erate* Esper, *Colias* (Pieridae):

Butler (1880, *Proc. Zool. Soc.*, p. 409) from Rokeran; Butler (1882, *Ann. Nat. Hist.*, (5) **9**:p. 208); Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 344) from Kandahar.

= *Colias pallida:* Butler [1882, *Ann. Nat. Hist.*, (5) **9**: 208]; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 344) from Kandahar.

Synonymy: Talbot, (1939, Fauna Br. India, Butterfly, 2nd Ed., **1**: 552).

According to Peile (1937, A Guide to the Collection of Butterflies in India, p. 65–68.) there had been a good deal of confusion regarding this species, some authors considering this only as a variety of *Colias hyale*, but he considers this as quite distinct. Maj. Robert's collection from Rokeran is well preserved in the Br. Museum, he says, and this is distinctly *C. erate*.

23. *euphorbiae robertsi* (Butler), *Celerio* (Sphingidae):

Bell and Scott (1937, Fauna Br. India, Moths, **5**: 403).

= *Deilephila robertsi:* Butler (1880, *Proc. Zool. Soc.*, pp. 412–413) from Rokeran; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 346) from Kandahar.

*24. *farinalis* Linnaeus, *Pyralis* (Pyralidae):

Butler [1882, *Ann. Mag. Nat. Hist.*, (5) **9**: 510]; Hampson (1896, Fauna Br. India, Moths, **4**: 449); Swinhoe (1885) *Trans. Ent. Soc.*, London, p. 353) from Kandahar.

25. *fausta fausta* (Oliver), *Colotis* (Pieridae):

= *Teracolus faustus:* Butler (1880, *Proc. Zool. Soc.*, p. 409) from Rokeran; Butler [1882, *Ann. Nat. Hist.*, (5) **5**: 209]; Swinhoe (1885 *Trans Ent. Soc.*, London, p. 345) from Kandahar.

= *Colotis fausta:* Bingham (1907, Fauna Br. India, Butterfly, **2**: 266–67).

Synonymy: Talbot (1939, Fauna Br. India, Butterfly, 2nd Ed., **1**: 461).

faustus (see *fausta*).

26. *ferrugalis* Hubner, *Pionea* (Pyralidae):

Hampson (1896, Fauna Br. India, Moths, **4**: 422); Hampson (1899, *Revis. Pyraust.*, p. 243).

= *Scopula ferrugalis:* Butler [1882, *Ann. Mag. Nat. Hist.*, (5) **9**: 211] Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 354) from Kandahar.

27. *floralis* Hubner, *Noctuaelia* (Pyralidae):

= *Herbula meleagrisalis:* Butler [1882, *Ann. Nat. Hist.*, (5) **9**: 211] from Kandahar.

= *Aporodes meleagrisalis:* Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 354) from Kandahar; Hampson (1896, Fauna Br. India, Moths, **4**: 445).

28. *florella* (Fabr.), *Catospila* (Pieridae):

Bingham (1907, Fauna Br. India, Butterfly, **2**: 223–24).

generator (see *pales*) form *iranica* (Bien.)

29. *glauconome* Klug., *Pontia* (Pieridae):

= *Synchloe iranica:* Butler (1880, *Proc. Zool. Soc.*, p. 410) from Rokeran; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 343) from Kandahar.

Synonymy: Talbot (1939, Fauna Br. India, Butterfly, 2nd Ed., **1**: 432).

30. *hastigera* Butler, *Loxospilates* (Geometridae):

Hampson (1895, Fauna Br. India, Moths, **3**: 182).

hyale (see *erate*)

*31. *helictha* Lederer, *Colias* (Pieridae):

Butler (1880, *Proc. Zool. Soc.*, pp. 408–409) from Rokeran; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 343) from Kandahar; Bingham (1907, Fauna Br. India, Butterfly, **2**: 234) considers this as synonymous with *Colias hyale*.

32. *hyalas* W. V., *Lycaena* (Lycaenidae):

Bingham (1897, Fauna Br. India, Butterfly, **2**: 351–52).

*33. *hierogly-phella* Rag., *Pamphila* (Pyralidae):

Zerny (1914, *Ann. K.K. Hoffmus., Wien*, **28**: 308) from 'Kuschk' N. Afghanistan.

hybridalis (see *noctuella*)

34. *icarus persica* (Biernet), *Polyommatus* (Lycaenidae):

= *Lycaena persica:* Butler [1880, *Proc. Zool. Soc.*, London, p. 407] from Rokeran; Butler (1882, *Ann. Nat. Hist.*, (5) **9**: 207) from Kandahar; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 340).

Synonymy: Peile (1937, Guide Coll. Butterfly, India, p. 178).

imbella (see *adaptella*).

*35. *immaculatella* Rag., *Myelois* (Pyralidae):

Zerny (1914, *Ann. K.K. Hoffmus., Wien*, **28**: 316) from 'Kuschk' N. Afghanistan.

36. *impurellus* Hampson, *Crambus* (Pyralidae):

Hampson (1896, Fauna Br. India, Moths, **4**: 16).

interposita (see *lupinus*).

iranica (see *glauconome*).

kafir (see *delphius*).

*37. *karsana* Moore, *Pamphila* (Hesperiidae):

Butler [1882, *Ann. Nat. Hist.*, (5) **9**: 209]; Swinhoe (1885, *Trans. Ent. Soc.*, p. 345) from Kandahar.

38. *kashmeriensis* Moore, *Craspedia* (Geometridae):

= *Acidalia ornata:* Butler [1882, *Ann. Nat. Hist.*, (5) **9**: 210]; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 352) from Kandahar.

Synonymy: Hampson (1895, Fauna Br. India, Moths, **3**: 430).

39. *kindermanii obsoleta* (Staudinger), *Smerinthus* (Sphingidae):

= *Eusmerinthus kindermanii:* Butler (1880, *Proc. Zool. Soc.*, p. 413) from Rokeran; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 346) from Kandahar.

= *Smerinthus kindermanii:* Hampson (1892, Fauna Br. India, Moths, **1**: 123).

Synonymy: Bell and Scott (1937, Fauna Br. India, Moths, **5**: 233).

*40. *kuschkella* Zerny, *Salebria ?* (Pyralidae):

Zerny (1914, *Ann. K.K. Hoffmus., Wien*, **28**: 313–314) from 'Kuschk' N. Afghanistan.

41. *laeta laeta* (Boisduval), *Eurema* (Pieridae):

= *Terias laeta:* Bingham (1907, Fauna Br. India, Butterfly, **2**: 248).

Synonymy: Talbot (1939, Fauna Br. India, Butterfly, 2nd Ed., **1**: 517).

ligaminosa (see *spectrum*).

42. *loewii chamanica* (Moore), *Polyommatus* (Lycaenidae):

= *Lycaena chamanica:* Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 340) from Kandahar.

Synonymy: Evans (1932, Ident. Indian Butterfly, p. 226).

43. *lupinus centralis* (Riley), *Maniola* (Satyridae):

= *Epinephele interposita:* Butler (1880, *Proc. Zool. Soc.*, pp. 405–406) from Rokeran; Butler [1882, *Ann. Mag. Nat. Hist.*, (5) **9**: 207]; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 338) from Kandahar.

Synonymy: Evans (1932, Ident. Indian Butterfly, p. 112).

*44. *manni* Mayer, *Ganoris* (Pieridae):

Butler (1880, *Proc. Zool. Soc.*, p. 411).

marrubii (see *boeticus*).

meleagrisialis (see *floralis*).

mesentina (see *aurota*).

negataria (see *remotata*).

45. *noctuella* Schiff., *Nomophila* (Pyralidae):

= *Stenopteryx hybridalis:* Butler [1882, *Ann. Nat. Hist.*, (5) **9**: 211]; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 354) from Kandahar.

Synonymy: Hampson (1896, Fauna Br. India, Moths, **4**: 401).

46. *obliquaria* Moore, *Loxospilates* (Geometridae):

Hampson (1895, Fauna Br. India, Moths, **3**: 181).

obsoleta (see *kindermanni*).

47. *ochreata* Moore, *Cidaria* (Geometridae):

Hampson (1895, Fauna Br. India, Moths, **3**: 352).

48. *ocellea* Eromen, *Eromene* (Pyralidae):

Hampson (1896, Fauna Br. India, Moths, **4**: 24).

ornata (see *kashmeriensis*)

ostrinalis (see *purpuralis*)

49. *pales korla* Fruh, *Argynnis* (Nymphalidae):

= *Argynnis pales* race *generator:* Bingham (1905, Fauna Br. India, Butterfly, **1**: 447).

Synonymy: Evans (1932, Ident. Indian Butterfly, p. 184).

pallida (see *erate*).

50. *parisatis* (Kollar), *Eumenis* (Satyridae):

= *Hipparchia parisatis:* Butler (1880, *Proc. Zool. Soc.*, p. 405) from Rokeran; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 38) Kandahar.

= *Nytha parisatis:* Bingham (1905, Fauna Br. India, Butterfly, **1**: 117).

Synonymy: Peile (1937, Guide Coll. Butterfly, *India*, p. 93).

persea (see *robertsi*).

persica (see *icarus*).

phantasma (see *spectrum*).

51. *phlaeas* Linnaeus, *Lycaena* (Lycaenidae):

Chrysophanus phlaeas: Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 340) from Kandahar.

Phlaeas stygianus Butler:

= *Chrysophanus stygianus* Butler (1880, *Proc. Zool. Soc.*, London, p. 408) from Rokeran.

= *Chrysophanus phlaeus* var. *stygianus:* Butler [1882, *Ann. Nat. Hist.*, (5) **9**: 208] from Kandahar.

= *Chrysophanus phlaeus* var. *timaeus:* Butler [1882, *Ann' Nat. Hist.*, (5) **9**: 208] from Kandahar.

Synonymy: Evans (1932, Ident. Indian Butterfly, p. 244).

52. *pinguinalis* Linnaeus, *Aglossa* (Pyralidae):

Butler [1882, *Ann. Mag. Nat. Hist.*, (5) **9**: 210]; Hampson (1896, Fauna Br. India, Moths, **4**: 148); Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 353).

53. *plagiata* Linnaeus, *Anaitis* (Geometridae):

Hampson (1895, Fauna Br. India, Moths, **3**: 342–43).

54. *pomonella* (Linnaeus), *Cydia* (Eucosmidae):

Janjua [1938, *Curr. Sci.*, Bangalore, **1** (3): 115–16).

55. *plexippus* (Linnaeus), *Danais* (Danaidae):

Butler (1880, *Proc. Zool. Soc.*, p. 405) from Rokeran.

56. *prolifica* Walker, *Catocalla* (Noctuidae):

Hampson (1894, Fauna Br. India, Moths, **2**: 441).

57. *pudicata* Guenee, *Anaitis* (Geometridae):

Hampson (1895, Fauna Br. India, Moths, **3**: 341–42).

58. *pulchella* Linnaeus, *Utetheisa* (Arctiidae):

= *Deiopeia pulchella:* Butler (1880, *Proc. Zool. Soc.*, p. 414) from Rokeran; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 347) from Kandahar.

= *Deiopeia thyter:* Butler [1882, *Ann. Nat. Hist.*, (5) **9**: 210]; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 347) from Kandahar.

*59. *purpuralis* (Linnaeus), *Pyrausta* (Pyralidae):

= *Pyrausta ostrinalis:* Butler [1882, *Ann. Mag. Nat. Hist.*, (5) **9**: 210]; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 353) from Kandahar.

Synonymy: Hampson (1899, *Rev. Pyraust.*, p. 267).

*60. *rapae* (Linnaeus), *Pieris* (Pieridae):

= *Ganoris manni:* Butler (1880, *Proc. Zool. Soc.*, p. 411) from Rokeran.

= *Ganoris rapae:* Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 343) from Kandahar, also synonymous with *manni*.

Synonymy: Talbot (1939, Fauna Br. India, Butterfly, 2nd Ed., p. 428).

61. *remotata* Guenee, *Craspedia* (Geometridae):

= *Idaea negataria:* Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 352) from Kandahar.

Synonymy: Hampson (1895, Faund Br. India, Moths, **3**: 433).

62. *robertsi robertsi* Butler, *Melitaea* (Nymphalidae):

= *Melitaea robertsii* Butler: (1880, *Proc. Zool. Soc.*, p. 406) from Rokeran; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 339) from Kandahar.

Synonymy: Evans (1932, Ident. Indian Butterfly, p. 185).

robertsi (see *euphorbiae*).

roxane (see *davendra*).

63. *sacraria* Linnaeus, *Rhodometra* (Geometridae):

= *Sterra sacraria:* Butler [1882, *Ann. Nat. Hist.*, (5) **9**: 210]; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 352) from Kandahar.

*64. *sarapetensis* Staudinger, *Colias* (Pieridae):

Butler (1880, *Proc. Zool. Soc.*, p. 409) from Rokeran; Butler [1882, *Ann. Nat. Hist.*, (5) **9**: 208]; Swinhoe (1885, *Trans. Ent. Soc.* London, p. 344) from Kandahar.

65. *segetum* (Schiff.), *Euxoa* (Noctuidae):

= *Agrotis aversa* Butler [1882, *Ann. Nat. Hist.*, (5) **9**: 210]; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 349) from Kandahar.

66. *signella* Rag., *Nephopteryx* (Pyralidae):

Hampson (1896, Fauna Br. India, Moths, **4**: 448).

67. *spectrum* Esp., *Amphipyra* (Noctuidae):

= *Apopestes phantasma* Butler (1880, *Proc. Zool. Soc.*, pp. 414–15) from Rokeran; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 351) from Kandahar.

= *Anthophila ligaminosa* Butler [1882, *Ann. Nat. Hist.*, (5) **9**: 210]; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 350) from Kandahar.

Synonymy: Hampson (1894, Fauna Br. India, Moths, **2**: 192).

68. *stellatarum* Linnaeus, *Macroglossum* (Sphingidae):

Butler [1880, *Ann. Nat. Hist.*, (5) **9**: 210]; Swinhoe (1885, *Trans. Ent. Soc.*, p. 347) from Kandahar.

69. *stipularis* Swinhoe, *Chaerochampa* (Sphingidae):

Hampson (1892, Fauna Br. India, Moths, **1**: 123).

stygianus (see *phlaeus*).

sulphuralis (see *trabealis*).

70. *thelephassa* Hubner, *Eumenis* (Satyridae):

= *Hipparchia thelephassa:* Butler (1880, *Proc. Zool. Soc.*, p. 405) from Rokeran; Butler [1882, *Ann. Mag. Nat. Hist.*, (5) **9**: 207]; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 339) from Kandahar.

= *Nytha thelephassa*: Hampson (1905, Fauna Br. India, Butterfly, **1**: 114).

Synonymy: Evans (1932, Ident. Indian Butterfly, p. 114).

*71. *terrealis* Treitschke, *Pyrausta* (Pyralidae):

Hampson (1899, *Revis. Pyraust.*, p. 255).

timaeus (see *phlaeus*).

thyter (see *pulchella*).

72. *trabealis* (Scopoli), *Emmelia* (Noctuidae):

= *Agrospila sulphuralis:* Butler [1882, *Ann. Nat. Hist.*, (5) **9**: 210]; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 351) from Kandahar.

= *tarache sulphuralis:* Hampson (1894, Fauna Br. India, **2**: 315).

73. *trivia persea* Koll., *Melitaea* (Nymphalidae):

= *Melitaea didyma* race *persea:* Bingham (1905, Fauna Br. India, Butterfly, **1**: 453).

*74. *turcomanicum* Chr., *Tegostoma* (Pyralidae):

Zerny (1914, *Ann. K.K. Hoffmus., Wien*, **28**: 337) from 'Kuschk', N. Afghanistan.

75. *undulans* Moore, *Agrotis* (Noctuidae):

Hampson (1894, Fauna Br. India, Moths, **2**: 183).

*76. *verticalis* Linnaeus, *Phyctaenodes* (Pyralidae):

Hampson (1899, *Revis. Pyraust.*, p. 208).

77. *vicrama cashmeriensis* (Moore), *Polyommatus* (Lycaenidae):

= *Scolitantides cashmeriensis:* Butler (1885, *Proc. Zool. Soc.*, p. 408) from Rokeran; Swinhoe (1885, *Trans. Ent. Soc.*, London, p. 341) from Kandahar.

Synonymy: Evans (1932, Ident. Indian Butterfly, p. 226).

APPENDIX B

The following is a list of Lepidopterous insects found in the collections of Mr. Hide Into of the College of Agriculture, Tokyo, Japan, who was teaching Entomology in the School of Agriculture, Kabul, during the time of the writer's visit to Afghanistan.

1. *Chilo simplex* (Butler): PYRALIDAE

This is bad pest of rice in Japan and Formosa. A closely allied species very common in India has been known for a very long time by this name, but Fletcher (Report of the Imperial Entomologist, India, 1926–27, p. 58) has shown that this cannot be the same as the *simplex* of the Far East and that the Indian species agrees with the description of *zonellus*. If so there is reason to think that the species recently reported is also not *simplex* and the occurrence of the same in Afghanistan is also doubtful.

2. *Cnaphalocrocis medianalis* Guenee: PYRALIDAE

This species has been known from throughout the Oriental and Australian regions. It is a pest of paddy, sometimes sporadically serious in India. Its presence in Afghanistan, if confirmed, will show its more extensive distribution.

3. *Dichocrocis punctiferalis* Guenee: PYRALIDAE

This species is known from Japan, China, throughout India, Burma and Ceylon, the Malayan subregion and the Australian region. It is mainly a pest of castor, boring into the capsules, but is known to attack a variety of plants belonging to different Natural Orders in India. Its distribution in Afghanistan, if confirmed, will be interesting.

4. *Pyrausta nubilalis* Hubner: PYRALIDAE

This is a bad pest of cereals more or less universally distributed. Its distribution in Afghanistan is, however, not so far known. In India and Egypt it is not yet known to do any serious damage.

5. *Schoenobius bipunctifer* Walker (*incertellus* Walker): PYRALIDAE

This is the paddy stem-borer of tropical Asia, recorded as a pest from India, Ceylon, Burma, the Straits Settlements, Malaya Islands, the Philippines and Formosa. This is not so far known to occur in Afgahnistan.

6. *Illiberis pruni* Dyar: ZYGAENIDAE

The distribution of this species, so far as is known, is limited to the Far East, *viz.*, Japan and China, and does not extend even to the eastern borders of India or even Burma. This is a pest of apple and pear in the countries where it occurs. Mr. Into's specimens are possibly from any of these places.

7. *Barathra brassicae* Linn.: NOCTUIDAE

This is distributed throughout the Palearctic Region including Europe, Asiatic Russia and Japan and extends to the northern limits of the Punjab in India. It is, therefore, likely that Mr. Into had his specimens locally collected.

8. *Euxoa segetum* Schiff.: NOCTUIDAE

This is one of the cutworms of universal distribution. It has been recorded from Afghanistan (Kandahar) as early as 1882 by Butler under the name *Agrotis aversa* Walker.

9. *Naranga aenescens* Moore: NOCTUIDAE

Like *Illiberis pruni* Dyar. this species is also so far known only from the Far East.—China, Japan and Formosa, and its distribution has not been known to extend even to Burma in the East. It is therefore likely that Mr. Into's collection is not locally made.

10. *Pieris rapae* Linn.: PIERIDAE

This has been recorded from Afghanistan as early as 1885 by Swinhoe. It has been collected from this country by the present writer too.

11. *Lymantria dispar* Linn.: LYMANTRIIDAE

This is the notorious gypsy moth found so widely distributed in the Neotropical and Palearctic regions. This has not been so far recorded from Afghanistan and therefore its distribution here, if confirmed, will be interesting.

ON THE IMMATURE STAGES OF SOME PSYLLIDAE

By R. N. MATHUR, M.SC., PH.D.

Systematic Entomologist, Forest Research Institute, Dehra Dun

INTRODUCTION

So little is known of the immature stages of Indian Psyllidae that it seems desirable to describe the nymphal stages of seven identified species. The investigation on Psyllidae was undertaken in 1931, under the guidance of Dr. C. F. C. Beeson, then Forest Entomologist. The biology of thirty-four species of Psyllidae occurring on forest trees has already been published by the present writer (1935). Short notes on the biology of two more species, *Apsylla cistellata* Buck. and *Phacopteron lentiginosum* Buck., are now included in this paper. The plan adopted by Ferris (1923) has been followed in describing the immature stages.

Grove and Ghosh (1914) gave a brief description of the nymphal stages of the indigo psylla, *Arytaina punctipennis* Crawf. Afzal Hussain and Dina Nath (1927) described fully the nymphal stages of the citrus psylla, *Diaphorina citri* Kuw. A brief description of the nymphal forms of *Phylloplecta gardneri* Laing from leaf-galls on *Populus euphratica* is given by Laing (1930). Rahman (1932) described the immature stages of *Pauropsylla tuberculata* Crawf. from the leaves of *Alstonia scholaris, P. depressa* Crawf. from galls on the leaves of *Ficus glomerata, Tenaphalara acutipennis* Kuw. from the leaves of *Bombax malabaricum*, *Arytaina punctipennis* Crawf. from *Indigofera* and *Trioza fletcheri* Crawf. from the leaves of *Trewia* sp.

All the drawings in this paper have been made with the aid of a camera lucida.

Sub-family *PAUROPSYLLINAE*

Apsylla cistellata Buckton

Food-plant.—ex galls formed of the buds of *Mangifera indica.*

Fifth stage (Fig. 1, A).—Length, male 2·82 mm., female 3·13 mm. The body, in general, of psylline type, elongate, robust, with swollen abdomen; wing-pads not produced forward. Derm membranous throughout except for a pair of small sclerotic plates on the head by the side of the eyes, small areas on the dorsum of the thorax, the wing pads and a small caudal area, beset with numerous minute points, arranged in close groups, comb-like processes and simple setae, arranged segmentally in the abdomen (Fig. 1, C).

Ventral side membranous throughout, and the derm beset with minute points; comb-like structures situated towards the centre and ring-based bristle-like setae arranged inter-segmentally (Fig. 1, D). Antennae ten-segmented, 0·81–0·92 mm. in length, long, slender, having small simple setae and bristle-like

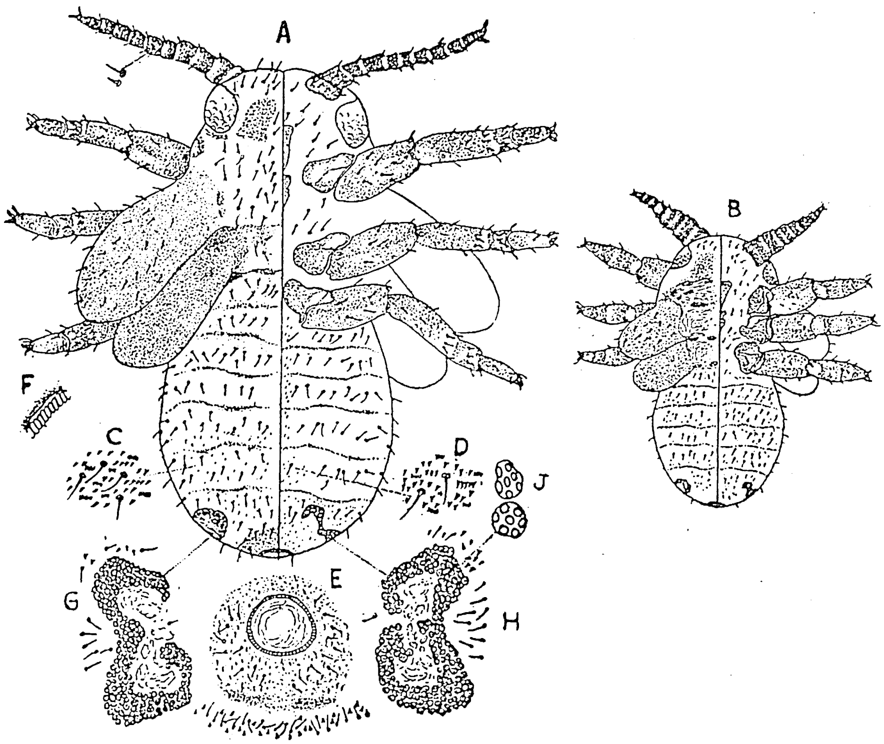

FIG. 1. *Apsylla cistellata* Buckton—A, Mature nymph ; B, 4th stage nymph ; C, D, comb-like processes and simple setae ; E, anal opening ; F, portion of slit-like pores of anal opening ; G, H, J, band of pores in caudal area.

setae; terminal segment with two spines. Sensoria not discernible. Legs long having bristle-like setae; without trochanter; with distinct tibiotarsal joint; with two prominent setae on the upper side of each second tarsal joint; claws present; pulvillus absent. Anal opening at the extreme tip of the body and enclosed within a small ring of slit-like pores (Fig. 1, E, F). The caudal area on either side with a large band of pores, lying partly on the dorsal and partly on the ventral side, but mainly dorsal in position. Each band (Fig. 1, G, H, J) composed of an outer series of conspicuous large pore areas and an inner series of poorly defined pore areas.

Fourth stage (Fig. 1, B).—Length 1·28 mm. Resembles the fifth stage, but with antennae eight-segmented, wing pads small, and tibio-tarsal articulation indistinct.

Biological notes.—This species appears to possess one life-cycle in a year at Dehra Dun. The cone-shaped, hard and tightly closed galls begin to open in March when the season warms up, and the dehiscence continues till mid-April. The overlapping scales of the gall unfold and the mature nymphs cast off their final

skin and transform into adult psyllids. Frequently adult psyllids are also found in unopened galls at this time of the year. Soon after emergence from the galls, the adults copulate. The pair remains side by side while *in coitu*. The eggs are laid in the tissues on the under side of mid vein of the new flush of leaves. The female when laying eggs faces towards the base of the leaf and slowly moves downward from the tip towards the base along the vein puncturing the tissue and inserting eggs singly in the punctures. The egg-deposition may occupy 1 to 6 inches of the vein. In a vein of about 4-inch length, as many as 166 eggs were counted. The egg-laid portion of the vein turns olive green in colour. The eggs, which are shining white, are clearly visible partly embedded in the punctures.

The nymphal stage is passed inside the new buds which become very conspicuous as cone-shaped galls in winter.

A species of *Psittacula* (Psittacidae) was observed to open the galls and feed on the nymphs in winter.

Pauropsylla beesoni Laing

Food-plant.—ex galls on leaves of *Litsaea polyantha*.

Fifth stage (Fig. 2, A).—Length 2·14 mm. Form pauropsylline. Body flattened. Wing-pads large and prominent, the humeral angle round and slightly produced forward up to the neck. Eyes large, many-faceted. Dorsum strongly sclerotic at the head, thorax and wing-pads, except along a dorsal median longitudinal membraneous streak; abdomen with six pairs of narrow sclerotic strips and a caudal plate. Derm slightly vermiculate and thickly beset with minute points and scattered bristle-like setae (Fig. 2, D) which are segmentally arranged in the abdomen. The apical plate of the abdomen bears minute fringed processes (Fig. 2, E).

Ventral side membraneous throughout except for small areas round spiracles and faint strips in the abdomen, as indicated. Derm thickly covered with minute points (Fig. 2, F) and bristle-like setae (Fig. 2, G). Antennae (Fig. 2, H) 0·64 mm. long and stout, eight-segmented, imbricate, bearing scattered bristle-like setae and minute points; segments 4th and 6th with one sensorium each and segment 8th with two sensoria; terminal segment with two spines at the apex. Legs relatively large, stout, beset with bristles and minute points, with trochanter, with the tibio-tarsal articulation well defined (Fig. 2, J); claws present, pulvillus simple and tubular. Anal aperture situated at the tip of the abdomen and surrounded by the circum-anal pore ring (Fig. 2, K) which is considerably expanded and interrupted medianally. The outer ring consists of numerous pores (Fig. 2, L) in cellular arrangement; the inner mass of pores is faintly discernible.

Fourth stage (Fig. 2, B).—Length 1·49 mm. Form oval; sclerotic plates on the abdomen large and broad; antennae six-jointed, with three sensoria; division between tibia and tarsus indistinct.

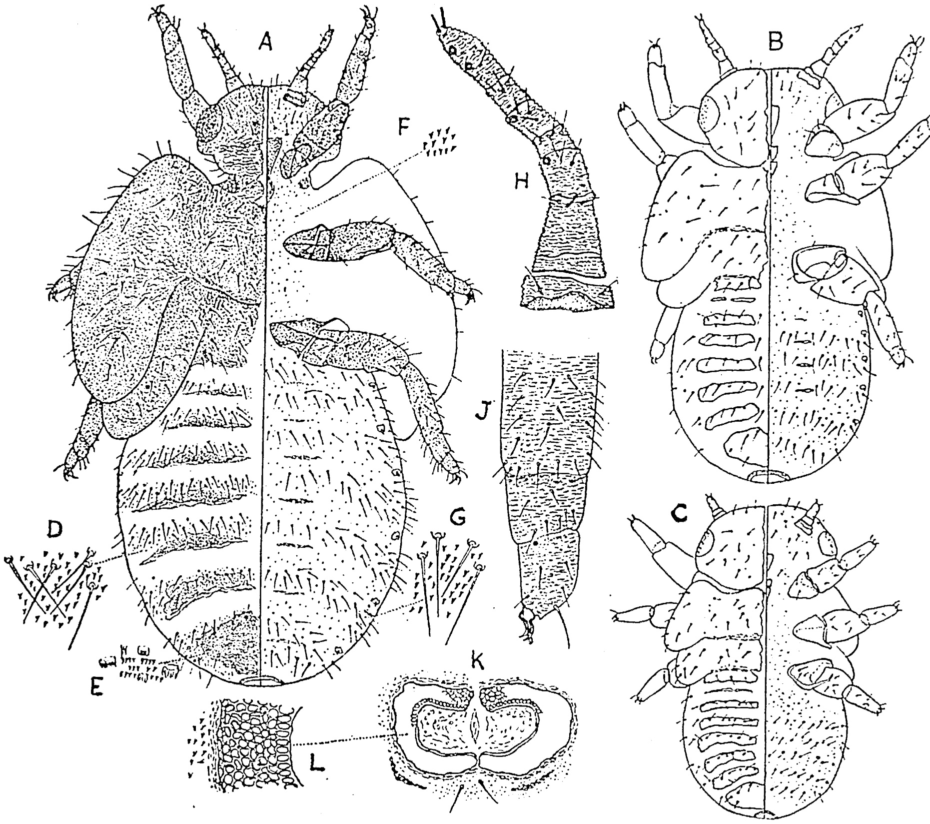

FIG. 2. *Pauropsylla beesoni* Laing.—A, Mature nymph ; B, 4th stage nymph ; C, 3rd stage nymph ; D, G, minute points and bristle like setae ; E, minute fringed processes ; F, minute points ; H, antenna of nymph ; J, tibio-tarsal articulation of nymph, with claws and pulvillus ; K, circum-anal pore ring ; L, portion of circum-anal pore ring of nymph.

Third stage (Fig. 2, C).—Length 0·93 mm. Resembles the fourth stage, but with antenna four-jointed having two sensoria; division between tibia and tarsus absent.

Second stage.—Length 0·51 mm. Very similar to the third stage; body sparsely beset with bristle-like setae; antennae two-segmented with one sensorium.

Phacopteron lentiginosum Buckton

Food-plant.—ex galls on leaves of *Garuga pinnata.*

Fifth stage (Fig. 3, A).—Length 2·9 mm. Body robust, the wing-pads projecting from the side of the body. Derm membranous over the greater part of the body, except the wing-pads, large head areas, small irregular strips of plates on the abdominal segments and a small caudal plate which are heavily sclerotised. The sclerotic head plates, thorax and abdominal strips are slightly

vermiculate. Derm beset with numerous small ring-based setae, minute stout points and sparingly with ring-based bristle-like setae (Fig. 3, E). Ventral side membranous, except for a small slightly sclerotic area around each spiracle and the derm is thickly beset with minute points and ring-based bristle-like setae which are slightly bigger than that of the dorsum (Fig. 3, F). Caudal segment bears fused minute points also. Antennae (Fig. 3, D), 0·55 mm. long, short, thick, situated slightly ventrally, three segmented; the third segment very long, strongly sclerotised, obscurely seven-segmented, bearing seven whorls of bristle-like setae and two blunt setae on the apical segmentation; four small sensoria present near the fourth, fifth, sixth and seventh whorl of setae. Legs stout, thickly bristly and bear numerous minute points; with trochanter; femora reaching margin

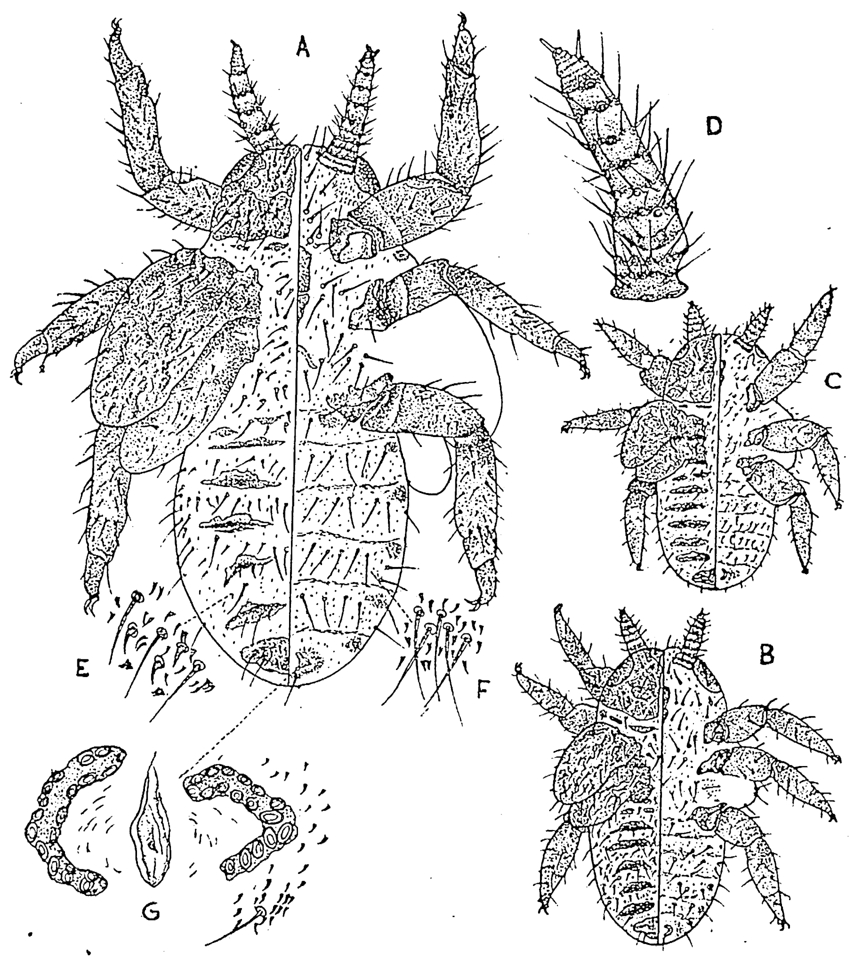

FIG. 3. *Phacopteron lentiginosum* Buckton.—A, Mature nymph; B, 4th stage nymph; C, 3rd stage nymph; D, antenna of mature nymph; E, F, minute points and bristle-like setae; G circum-anal pore ring of nymph.

of the body; tibio-tarsal articulation distinct; claws present; pulvillus somewhat tubular. Anal opening ventral and surrounded by a pore ring interrupted anteriorly and posteriorly (Fig. 3, G).

Fourth stage (Fig. 3, B).—Length 1·33 mm. Differing from the fifth stage in being smaller in size; having smaller wing-pads; third antennal segment with six obscure segmentations and two sensoria; in the absence of tibio-tarsal joints; and circum-anal ring with a less number of pores.

Third stage (Fig. 3, C).—Length 1·16 mm. Resembling the fourth stage but having broader sclerotic abdominal plates and thoracic areas; antennae two-segmented, second segment with five obscure segmentations.

Second stage.—Length 0·75 mm. Derm mostly sclerotic; wing-pads knob-like; antennae two-segmented, second segment indistingtly three-segmented.

First stage.—Length 0·34 mm. Identical with the second stage; wing-pads absent; body with few bristle-like setae which are mostly present along the margin; antennae one-segmented.

Seasonal history.—This species undergoes three cycles in a year at Dehra Dun. The overwintering galls begin to dehisce sometime in mid-February according to season and the dehiscence of the galls continues till end of March. The psyllids on emergence copulate immediately and the females start laying eggs, singly or in clusters, on the young buds and new flush of leaves. The gall-formation commences in early April and, by the end of April, the galls become fully developed and the nymphs inside are mature. These galls start opening in mid-May and continue to do so till early June. The female adults of this spring generation oviposit on the young leaves and the nymphs on hatching develop galls during the end of June. In July the galls are fully mature. These summer generation galls split in early August and the psyllids coming out of these galls also oviposit on the leaves. The galls are again formed by the nymphs hatched from these eggs. The galls enlarge gradually in winter. These winter generation galls are thick-walled and hard as compared to the spring and summer galls which are soft and thin-walled. By mid-December the nymphs in some galls transform into adult psyllids which remain inside the galls till dehiscence in spring. A gall may harbour as many as 6 nymphs inside. The psyllids, when removed from the galls in winter, remained alive in glass jars for about 2 months.

One female laid 147 eggs during a period of 5 days in March 1935.

Parasites and predators.—The nymphs are extensively parasitised by a Chalcidoid parasite. The parasite larva eats up the internal tissues of the mature nymph, leaving the skin intact. The parasite emerges by cutting a round hole in the abdominal skin of the host.

Adults of *Zosterops palpebrosa* Temm. & Schlegel (Zosteropidae) have been observed to break open the galls to feed on the nymphs during summer.

Sub-family *PSYLLINAE*

Euphalerus vittatus Crawford

Food-plant.—On developing buds of *Cassia fistula.*

Fifth stage (Fig. 4, A).—Length 1·91 mm. Psylline form; wing-pads small, not produced cephalad but project from the side of the body. The derm is membranous except for the sclerotic head-plates, wing-pads, apical abdominal plate and small areas on the thorax and abdomen, as figured. The body is thickly beset with minute points and scattered simple ring-based setae (Fig. 4, D). The apical abdominal plate is ornamented with minute comb-like structures (Fig. 4, E) and a much convoluted band of simple pores arranged in clusters (Fig. 4, F, G) on either side of the plate. Six small, slender, sharply-pointed dagger-shaped setae (Fig. 4, H) are present at the margin of the apical plate.

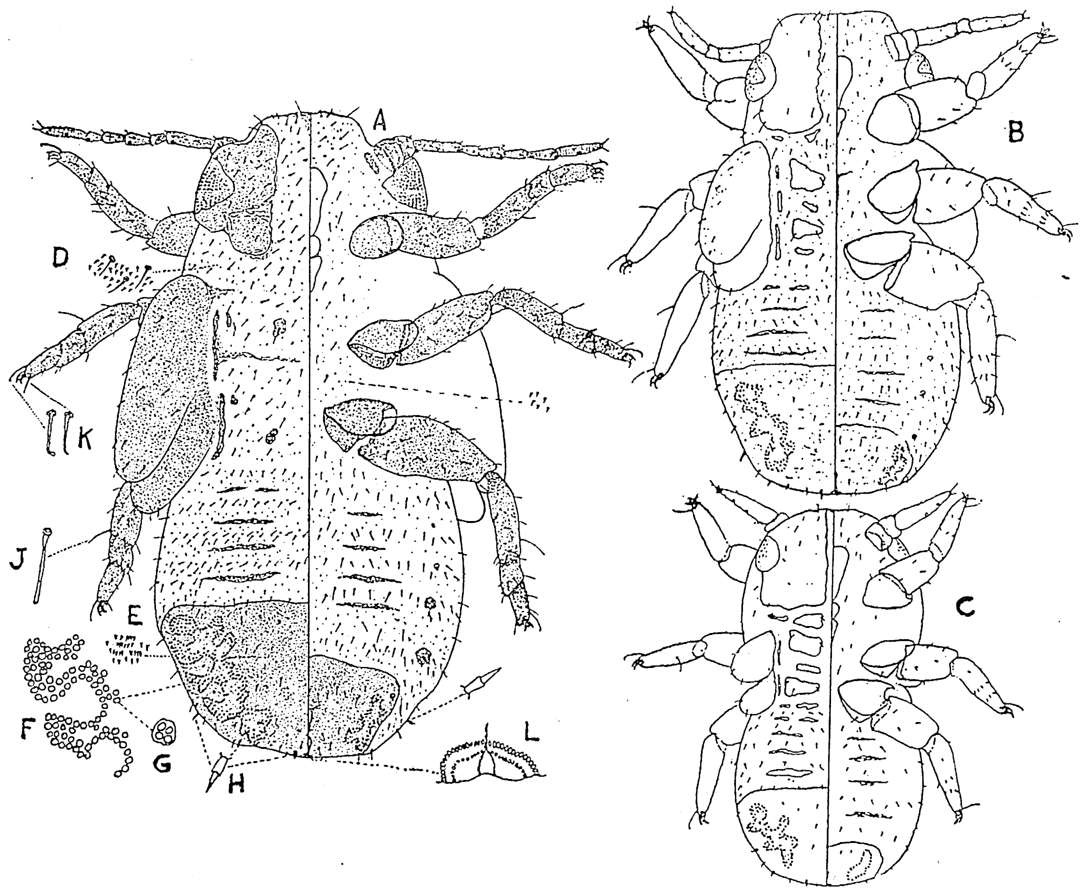

FIG. 4. *Euphalerus vittatus* Crawford.—A, Mature nymph; B, 4th stage nymph; C, 3rd stage nymph; D, minute points and simple setae; E, minute points; F, G, portion of band of pores; H, dagger-shaped seta; J, K, spatulate setae; L, portion of circum-anal pore rings and anal opening.

Ventral side membranous throughout except for small sclerotic areas at the base of each antenna, about each spiracle, four pairs of narrow submedian strips in the abdomen and a large caudal plate. Derm heavily covered with minute points and simple setae. The caudal plate is similarly furnished with fringed processes and a less convoluted band like the dorsal apical abdominal plate. Antennae are situated on the ventral side; 0·61 mm. long and slender, eight-segmented having few simple setae and conspicuous sensoria on the third, fifth, seventh and eighth segments; third segment long, showing weak constriction in the middle; apical segment imbricate, bearing two spines at the tip. Legs long, having simple setae; without trochanter; with distinct tibio-tarsal division; tibia of the middle and hind pair with a long spatulate seta (Fig. 4, J); tarsus with a single golf-club-shaped seta and a small spatulate seta (Fig. 4, K); claws present, median and lateral sclerites distinct, with a long tendon running up to the femur; pulvillus long and tubular. Anal opening (Fig. 4, L) terminal, surrounded by a double ring of slit-like pores, interrupted medianally.

Fourth stage (Fig. 4, B).—Length 1·12 mm. Resembles the fifth stage in general characters but differs in having antennae five-segmented with three sensoria; thoracic and abdominal plates large, as illustrated; wing pads small and tibio-tarsal articulation absent.

Third stage (Fig. 4, C).—Length 0·63 mm. Differing from the fourth stage in possessing antennae three-segmented with two sensoria and wing-pads smaller and knob-like.

Sub-family *TRIOZINAE*

Phylloplecta hirsuta Crawford

Food-plant.—ex leaf galls on *Terminalia tomentosa.*

Fifth stage (Fig. 5, A).—Length 3·24 mm. Triozine form; the wing-pads are large and produced forward almost to the posterior margin of the eyes. The head, thorax and wing-pads are sclerotic except for the membranous area along the median line. The abdomen is membranous throughout except for six pairs of submedian sclerotic strips and a small area near the apex of the abdomen, close to the circum-anal ring. Derm poorly vermiculate in the head, thorax and wing-pads and densely beset with minute points and simple ring-based setae of various sizes (Fig. 5, D, F). In the abdomen the minute points are faintly discernible. The caudal zone bears comb-like structures (Fig. 5, E) and two lanceolate setae close to the circum-anal ring. Few small slender and sharply-pointed dagger-shaped seate (Fig. 5, F) are also present along the margin of the abdomen.

Ventral side is membranous throughout except for small areas around each spiracle and six pairs of thin submedian abdominal strips. Derm thickly beset with minute points (Fig. 5, G) and simple ring-based setae. Antennae are situated ventrally, short and slender, 0·89 mm. long, eight-segmented, having few simple setae and four sensoria, last five segments imbricate; terminal segment long,

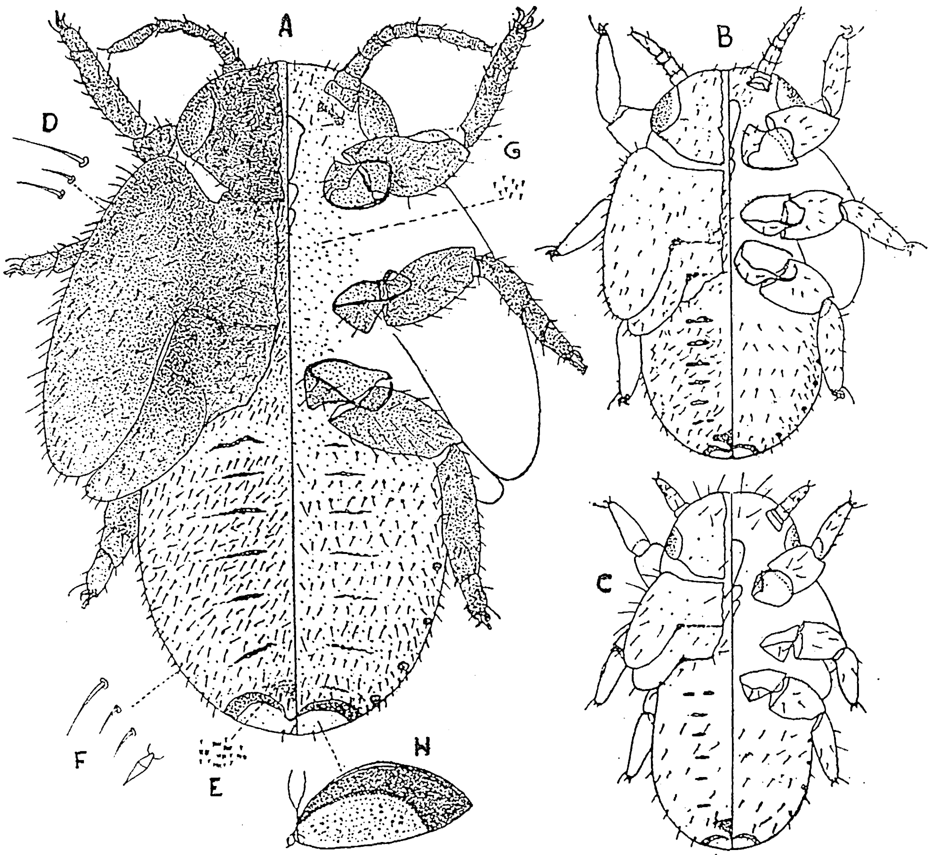

FIG. 5. *Phylloplecta hirsuta* Crawford.—A, Mature nymph ; B, 4th stage nymph ; C, 3rd stage nymph ; D, F, simple setae and dagger-shaped seta ; E, comb-like structures ; G, minute points ; H, portion of ring of pores and anal-opening.

weakly constricted in the middle, bearing two unequal apical spines. Legs are short, bearing simple setae; without trochanter; articulation between tibia and tarsus distinct; claws present; pulvillus large and pyriform. Anal-opening is at the apex of the abdomen, and surrounded by an outer, considerably expanded ring of great numbers of minute circular pores (Fig. 5, H) with a single row of slit-like pores along its inner margin. The second ring is enclosed within this ring and is composed of more minute and much less conspicuous pores. The circum-anal-ring lies partly on the dorsal and partly on the ventral side.

Fourth stage (Fig. 5, B).—Length 1·66 mm. Resembles the fifth stage, having stout, six-segmented antennae with three sensoria; tibio-tarsal articulation absent.

Third stage (Fig. 5, C).—Length 0·95 mm. Differs from the fourth stage in having smaller wing-pads; antennae four-segmented with two sensoria; tibio-tarsal division absent; pulvillus tubular.

Second stage.—Length 0·50 mm. Wing-pads knob-like; antennae three segmented, with one sensorium. Abdomen bears lanceolate setae.

First stage.—Length 0·30 mm. Dorsal surface sclerotic. Antennae two-segmented, with two long apical spines. Pulvillus kidney-shaped.

Phylloplecta malloticola Crawford

Food-plant.—ex galls on leaves of *Mallotus philippinensis.*

Fifth stage (Fig. 6, A).—Length 2·32 mm. Form triozine, narrowly oval but the continuity of the margin is interrupted across the posterior portion of the head and at the base of the abdomen which are narrower than the wing-pads.

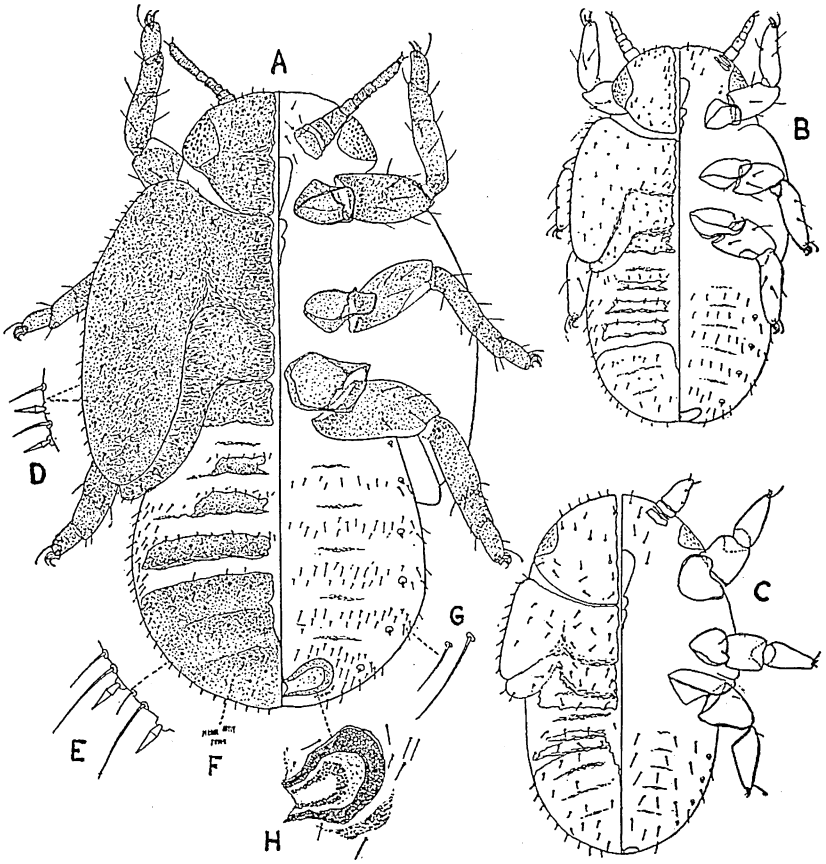

FIG. 6. *Phylloplecta malloticola* Crawford.—A, Mature nymph ; B, 4th stage nymph ; C, 3rd stage nymph ; D, E, G, bristle-like setae and dagger-shaped setae ; F, fringed processes ; H, portion of circum-anal pore rings.

Wing-pads are produced cepalad almost to the posterior margin of the eye. Dorsum with the derm sclerotic, the sclerotization broken up into four pairs of mesally separated narrow plates on each of the first four abdominal segments

while the caudal plate shows some traces of segmentation. Derm somewhat vermiculate and is beset with scattered small, slender sharply pointed dagger-shaped setae and small bristle-like setae (Fig. 6, D, E) which are also present along the body margin and head. Some bristle-like setae are present along the sides of the abdomen. The fourth abdominal and caudal plates are furnished with minute fringed processes (Fig. 6, F).

Ventral side membranous throughout, except for small portions about each spiracle, thin abdominal strips and a pair of small plates below the circum-anal ring. Derm beset with scattered simple and bristle-like setae (Fig. 6, G). Antennae are borne on the ventral side of the head; 0·41 mm. long and stout, eight-segmented, bearing four sensoria; last five segments imbricate; terminal segment shows traces of segmentation and bears two unequal spines at the tip. Legs large and stout, sparsely beset with bristle-like setae and a single golf-club-shaped seta on the tarsus; without trochanter; with two articulations between tibia and tarsi, one distinct and the other faint; claws present; pulvillus small, somewhat tubular. Anal opening is situated slightly away from the tip of the abdomen on the ventral side. It is surrounded by an outer, considerably expanded circum-anal pore ring, consisting of cellular structure in addition to the usual row of pores (Fig. 6, H). The inner ring is composed of a number of small, circular pores. Both the rings are interrupted medianally, in front and behind.

Fourth stage (Fig. 6, B).—Length 1·13 mm. Very similar to the fifth stage in form but with few simple and bristle-like setae; with antennae six-segmented bearing three sensoria, and without tibio-tarsal articulations.

Third stage (Fig. 6, C).—Length 0·71 mm. Resembling the fourth stage but with smaller wing-pads, few lanceolate setae; antennae appear to be four-segmented with two sensoria. Anal opening is more or less terminal in position.

Second stage.—Length 0·41 mm. Quite identical with the third stage but with wing-pads knob-like. Antennae two segmented, with one sensorium. Claws like small spines.

Trioza jambolanae Crawford

Food-plant.—ex galls on leaves of *Eugenia jambolana*.

Fifth stage (Fig. 7, A).—Length 2·95 mm. Typical triozine form, broadly oval; the humeral angle of the wing-pads produced forward almost to the anterior margin of the eyes and rounded. Dorsum with the derm strongly sclerotic except for the intersegmental membranous portions of the abdomen. Derm somewhat vermiculate and thickly beset with minute points (Fig. 7, E) except on the head and thorax and also bearing scattered minute sharply pointed ring-based spines. The fifth narrow sclerotic plate on the abdominal segment sparsely ornamented with minute fringed structures (Fig. 7, F) which cover densely the hind plate. Entire margin of the body except the eyes, beset with a continuous series of short sectasetae (Fig. 7, G).

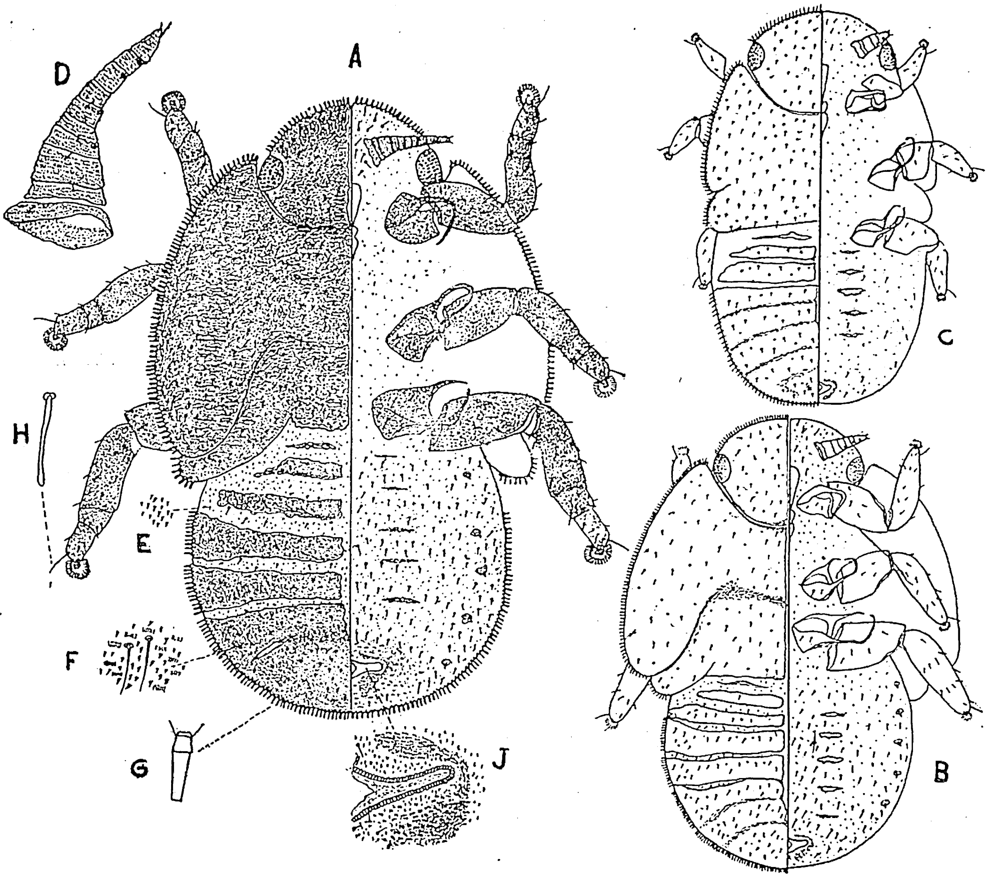

FIG. 7. *Trioza jambolanae* Crawford.—A, Mature nymph ; B, 4th stage nymph ; C, 3rd stage nymph ; D, antenna of mature nymph ; E, minute points ; F, fringed structures ; G, secta-seta ; H, spatulate seta ; J, portion of circum-anal pore ring.

Ventral side membranous throughout, except for small sclerotic areas round the circum-anal ring and the spiracles; the derm beset thickly with minute points and sharply pointed simple ring-based bristle-like setae on the abdomen and head.

Eyes quite small. Antenna (Fig. 7, D) short, 0·35 mm. long, stout, ten-segmented, imbricate, bearing rows of minute points and few simple setae; third segment large and broad; segments 4, 6, 8 and 9 bearing conspicuous sensoria; apical segment with two apical bristles, one pointed and the other blunt. Legs large and stout, having simple setae and thickly beset with minute points; without trochanter; with two tarsal joints, second tarsal segment with a single spatulate seta (Fig. 7, H); claws absent; pulvillus large, in the form of horse-shoe shaped pad. Anal aperture situated on the ventral side of the abdomen, surrounded by an outer single row of oval pores (Fig. 7, J); the inner ring consisting of minute pores, discernible under high magnification.

Fourth stage (Fig. 7, B).—Length 2·31 mm. Resembling the fifth stage in form, except for small size; antennae seven-segmented, having three sensoria; indication of tibia-tarsal joints faint.

Third stage (Fig. 7, C).—Length 1·97 mm. Like the fourth stage, narrowly oval; antennae indistinctly five-segmented, with two sensoria; tibio-tarsal joints absent.

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SHORT NOTES AND EXHIBITS

Occurrence of *Psyllia pyricola* Forst. on apple and pear trees in Kamaun.

The apple sucker, *Psyllia mali* Schmidb., and the pear psylla, *P. pyricola* Forst. (Psyllidae), are two of the most serious pests of apple and pear trees, respectively, in many parts of the world. In India, Psyllids have not been reported to be occurring on temperate fruit trees, except for two records of specifically unidentified species of *Psyllia*, recorded as pests of pear trees in the North-West Frontier Province by Pruthi and Batra (1938) and in Baluchistan by Janjua and Samuel (1941). It appeared, therefore, interesting to observe all stages of a Psyllid occurring on apple and pear trees in the Government Orchards at Chaubattia-Ranikhet in 1946 for the first time. This Psyllid has since been identified as *Psyllia pyricola* Forst. by Dr. K. B. Lal, Entomologist to Government, U.P. Further observations have shown that this species is fairly well distributed throughout the Kamaun hills, though not in a pest form.

Since *P. pyricola* is a notorious pest species, some observations were made on its biology. The adults, which over-winter in the crevices of bark of the host trees and in the grass beds below, appear on apple and pear trees early in March and start mating. Egg-laying commences by the middle of March on apple and towards the end of this month on pear trees. The eggs are generally laid on the under surface of the newly-opened apple leaves and on the outer surfaces of the unopened leaf buds of pear trees. They are creamy white when freshly laid but turn yellow afterwards and have a short, stout stalk at the proximal and a long, filamentous process at the distal end. Hatching takes place within 3–4 days of egg-laying. The first two nymphal instars, which have no wing pads, develop in 10–12 days and the remaining three, which have wing pads, in 20–22 days. Thus one generation is completed in about five weeks during March-April. Reproduction beyond the first generation in spring has not yet been observed.

The over-wintered adults are reddish brown with dark markings on the abdomen but the adults of the first generation are of two types. Some of them have reddish brown ıbdomen, like the over-wintering adults, while others have gıeenish abdomen. Two features of the biology deserve special mention. At no stage were the nymphs observed secreting any white, waxy substance. Secondly, both, apple and pear trees serve as hosts of the species. Both these facts are not in accord with the habits of *P. pyricola* as observed in countries outside India.

My thanks are due to Dr. K. B. Lal, Entomologist to Government, U.P., for first suggesting to me to look for Psyllids on apple and pear trees in Kamaun, for identifying the present species and for correcting the manuscript of this note.

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Z. A. Siddiqi.

Chaubattia-Ranikhet.

A serious outbreak of Eupterotid caterpillars on *chilbil* trees at Lucknow.

In October, 1945, unusually large numbers of a hairy caterpillar, probably of the genus *Eupterote* (family Eupterotidae), were observed on *chilbil* (*Ulmus integrifolia*) trees growing on both sides of the Outram Road, Lucknow. In an avenue of about three-fourths of a mile, almost every *chilbil* tree was affected.

The caterpillars were highly gregarious during day time and formed, on the tree trunks, thick compact masses which, in some cases, were 8′–9′ long and 1′–2′ broad. Some Sarcophagid flies were observed hovering near the caterpillars and were later found to be parasitic on them. Any mechanical disturbance caused a colony to break up and individual caterpillars started falling rapidly on the ground. It took them 1–2 hours to reform again into a compact mass.

The caterpillars fed on *chilbil* leaves during night time. With the onset of night, the colonies broke up and the caterpillars ascended the branches to feed. So numerous were they that the falling of their faecal pellets on the lower leaves during night time produced a sound resembling that of the falling of rain drops. Curiously enough, on the whole, the damage done to leaves was not so great as the numbers of the caterpillars warranted.

The caterpillars were found to pupate under faecal heaps, underneath the trees, in cocoons formed of larval hairs, earth and faeces all glued together. The pupation in nature took place during November 1945 when larvae, kept under laboratory conditions, also pupated in a similar manner. Moths emerged in the laboratory at the end of April, 1946. Some emergences also took place during July–August, 1946.

These caterpillars were destroyed by means of flame throwers.

Kanpur. P. L. CHATURVEDI.

PROCEEDINGS OF THE ENTOMOLOGICAL SOCIETY OF INDIA, 1946

Delhi Branch—New Delhi

4th July

Communication—

The limitation of the mid-rib theory in relation to the incidence of top borer attack on sugarcane—E. S. Narayanan.

18th October

Communications—

The biological notes on *Coranus spiniscutis* Dist. (Reduviidae)—M. Bose.

A severe outbreak of *Macropes excavatus* Dist. (black bug of sugarcane) in Sind—M. Haroon Khan.

The bionomics of *Nimboa basipunctata* Withy Comb (Coriopterygidae–Neuroptera) a predator on the eggs of *Pyrilla* spp.—E. S. Narayanan.

Exhibit—

Adults of *Argopistes limbatus* Motsch at jasmine—Ramdass Menon.

United Provinces Branch—Cawnpore

20th July

Communication—

Collection of insect fauna of Cawnpore—R. N. Singh.

Exhibits—

Larvae of *Margaronia caesalis* Wlk. from jack fruit (recorded in U.P. for the first time)—K. B. Lal.

Adults of *Alissonotum* sp. from roots of sugarcane in Lakhimpur, U.P. (hitherto recorded only from Burma and Assam)—K. B. Lal.

Baluchistan Branch—Quetta

6th October

Exhibits—

Mode of attack on almond leaves by the red spider mite (*Tetranychus telarius* Zell.)—Badarul Haq.

Mode of hibernation of the larvae of *Spilonota ocellana* Schiff.—S. M. Mahmood.

Bombay Branch—Poona

26th July

Communication—

Incidence of *Dermestes* beetle in dehydrated meat—K. N. Trehan.

23rd August

Communication—

Aphididae of Bombay—H. L. Kulkarny.

15th October

Hairy caterpillars of economic importance—G. M. Talgeri.

15th November

Communication—

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*55. HUSAIN, M. AFZAL, 56, Jail Road, P.O. Forman Christian College, Lahore.
56. HUSAIN, S. M. KHATIB, Assistant Professor, 13, Starky Town, Nagpur.
§57. IMMS, A. D., Zoological Laboratory, Cambridge (England).
58. ISAAC, P. V., Palathunkal Kottyam, Travancore.
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60. JANJUA, NAZEER AHMAD, Fruit Experimental Station, Quetta, Baluchistan.
61. JOLLY, CHAMAN LAL, Indian Agricultural Research Institute, New Delhi.
62. JOSEPH, M. THOMAS, Division of Entomology, Indian Agricultural Research Institute, New Delhi.
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74. KULKARNI, H. L., Agricultural College, Poona.
75. KUMAR, H. KRISHNA, Assistant, Fluted Scale Control Scheme, Sheshadri Road, Bangalore.
76. LAKSHMANAN, K., Assistant Area Control Officer, Ordnance Depot, Bombay 15.
77. LARI, FAIYAZ AHMAD, Indian Agricultural Research Institute, New Delhi.
78. LAL, HARBANS, I.G.S., Post Box 127, Cawnpore.
*79. LAL, K. B., Entomologist to Government, U.P., Cawnpore.
80. LAL, RATTAN, Indian Agricultural Research Institute, New Delhi.
‡81. LATIF, AGHA ABDUL, 14, Abbott Road, Lahore.
82. MAHMOOD, S. M., Entomological Assistant, Bostan (Baluchistan).
83. MANI, M. S., St. John's College, Agra.
84. MANOCHA, B. D., Locust Technical Officer, Bhuj, Kutch State.
§85. MARSHAL, GUY A. K., Imperial Institute of Entomology, 41, Queen's Gate, London S.W. 7.

* Foundation Member. ‡ Life Member.
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*86. MATHUR, C. B., Indian Agricultural Research Institute, New Delhi.
†87. MATHUR, I. D., Indian Agricultural Research Institute, New Delhi.
*88. MATHUR, R. N., Forest Research Institute, P.O. New Forest, Dehra Dun.
89. MEHRA, R. N., Entomological Assistant, Loralai (Baluchistan).
*90. MEHTA, D. R., Entomologist, Public Health Department, Lahore.
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96. MORTON, J. W., Central Officer, I.S.S.P., I.G.S., Cawnpore.
*97. MUKERJEE, D. D., Zoological Laboratory, 35, Bullygunge Circular Road, University College of Science and Technology, Calcutta.
†98. MUKERJEE, P. B., Indian Agricultural Research Institute, New Delhi.
*99. MUKERJEE, S., Indian Agricultural Research Institute, New Delhi.
100. NAQVI, SHABBAR HUSAIN, Kashmir Forest Service, P.O. Kiran, Muzzaffarabad.
101. NARAYANAN, E. S., Indian Agricultural Research Institute, New Delhi.
102. NASIR, S. M., Care Director of Agriculture, Quetta, Baluchistan.
103. NATH, DINA, Indian Agricultural Research Institute, New Delhi.
104. NATESAN, S., Care Associated Cement, Ltd., Porbander, Kathiawar.
‡105. NEGI, P. S., Indian Lac Research Institute, P.O. Namkum, Ranchi.
106. NEWMAN, J. F., Biological Branch, I.G.S., Cawnpore.
*107. NIGAM, L. N., Plant Protection, Quarantine and Food Storage Directorate, Jamnagar House, New Delhi.
108. PATEL, G. S., Government Entomologist, Agricultural Research Laboratory, Tejgaon' Dacca.
109. PHILIP, ANNAMA (MISS), Indian Agricultural Research Institute, New Delhi.
110. PERTI, S. L., S.S.A., Biological Branch, I.G.S., Cawnpore.
111. PINGLE, S. V., Agricultural College, Poona.
112. PRADHAN, S., Indian Agricultural Research Institute, New Delhi.
*‡113. PRUTHI, H. S., Plant Protection Adviser to Government of India, New Delhi.
114. PURI, I. M., Entomologist, Malaria Institute of India, Delhi.
115. QADRI, M. A. H., Zoology Department, Muslim University, Aligarh.
116. QADRIUDDIN, MD., Entomologist, Nizam's Government, Himayat Sagar, Hyderabad.
117. QURESHY, A. H., Entomological Section, Govt. Fruit Experimental Station, Quetta.
118. QURESHY, B. H., Entomological Assistant, Rani Bagh, Karachi.
119. QUTUBUDDIN, M., Medical Entomologist, Malaria Department, Hyderabad (Dn.).
*120. RAHMAN, KHAN A., Punjab Agricultural College, Lyallpur.
121. RAHMAN, M. ATIQUR, Punjab Agricultural College, Lyallpur.
122. RAKSHPAL, R., Department of Zoology, The University, Lucknow.
123. RAMACHANDRAN, S., Agricultural College and Research Institute, Coimbatore.
124. RANJAH, A. R., Zoological Survey of India, Kaiser Castle, Benares Cantt.
125. RAO, RANGA, P. N., Biology Department, Fergusson College, Poona.
126. RAO, T. RAMACHANDRA, Entomologist, Public Health Department, Sirsi (N. Kanara).
127. RAO, V. P., Plant Protection, Quarantine and Storage Directorate, Jamnagar House, New Delhi.
128. RAO, Y. RAMACHANDRA, 199, Market Road, Visveswarapuram, P.O. Bangalore.
129. ROY, D. N., Calcutta School of Tropical Medicine, Calcutta.
130. SAGAR, VIDYA, Khalsa College, Amritsar.
131. SAKSENA, S. P., S.S.A., Biological Branch, I.G.S., Cawnpore.

* Foundation Member. ‡ Life Member.
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*132. Samuel, C. K., Indian Agricultural Research Institute, New Delhi.
133. Sandhu, B. S., Indian Forest College, P.O. New Forest, Dehra Dun.
134. Santappa, Rev. Fr. H., Cruikshank Road, Bombay.
135. Sen, A. C., Entomologist to Government of Bihar, P.O. Sabour.
136. Sen, S. K., Care A. Sen, Esq., Deputy Collector, Agra.
137. Shabir, G., Locust Technical Officer, Jaipur.
138. Shah, Gobind Ram, Care L. Sarab Narain Ghadiok, Chakwal, Dist. Jhelum, Punjab.
139. Shah, S. Abdullah, Punjab Agricultural College, Lyallpur.
140. Sharif, M., Haffkine Institute, Parel, Bombay.
141. Sharma, S. N., Manager of Farm, S.H. Sugar Mills, Ltd., Motihari (Bihar).
142. Shirole, B. G., Biology Department, Fergusson College, Poona.
143. Sikka, H. L., Technical Assistant, Plant Protection, Quarantine and Storage Directorate, New Delhi.
144. Singh, Ajit, Locust Sub-Station, McLeod Road, Karachi.
†145. Singh, Arjun, Department of Food (Storage), New Delhi.
146. Singh, Chhote, Entomology Section, Agricultural Gardens, Cawnpore.
*147. Singh, Gurucharan, Assistant Entomologist, Jullundur.
148. Singh, Gurdas, Locust Sub-Station, McLeod Road, Karachi.
149. Singh, Jaswant, Loust Technical Officer, Jaisalmer.
150. Singh, Karam, Robertson College Colony, Jubbulpur.
*151. Singh, Mohan, Department of Food (Storage), New Delhi.
152. Singh, Prithipal, Locust Sub-Station, McLeod Road, Karachi.
153. Singh, R. N., Entomological Section, Department of Agriculture, U.P., Cawnpore.
154. Singh, Sardar, Plant Protection, Quarantine and Storage Directorate, Jamnagar House, New Delhi.
155. Singh, Sardul, Locust Sub-Station, Jodhpur.
156. Singh, Seva, Locust Sub-Station, McLeod Road, Karachi.
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158. Sitaraman, N. L., 12, Krishna Street, Basavangudi, P.O. Bangalore City.
159. Sontakay, K. R., Department of Food (Storage), New Delhi.
160. Srivastava, K. N., Zoology Department, University, Allahabad.
161. Srivastava, P. D., Entomology Section, Agricultural Gardens, Cawnpore.
162. Subhanulhuq, Syed, 5, Zainalabdin Road, Muslim University, Aligarh.
163. Subramaniam, T. V., Agricultural College and Research Institute, Coimbatore.
164. Talgeri, G. M., Agricultural College, Poona.
165. Thomas, P. M., Technical Assistant, Plant Protection, Quarantine and Storage Directorate, New Delhi.
*166. Trehan, K. N., Agricultural College, Poona.
167. Upadhyayulu, V. C., Fluted Scale Control Scheme, Sheshadri Road, Bangalore City.
168. Venkatraman, T. V., Indian Lac Research Institute, P.O. Namkum, Ranchi.
169. Verma, P. M., Agrcultural College, Poona.
170. Verma, R. M., Entomology Section, Agricultural Gardens, Cawnpore.
171. Vevai, E. J., Agricultural College, Poona.
172. Wattal, B. L., Indian Agricultural Research Institute, New Delhi.
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24. Entomological Assistant, Model Farm, Baroda.
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15. Joint Director of Agriculture, I/c., Post Box No. 412, Triplicane, Madras.	The Principal, Agriculture College, Bapatla, Guntur Dist., Madras Presidency, India.
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